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Efficiency and Effectiveness of Requirements Elicitation Techniques for Gathering Requirements from Children

Bachelor of Science Thesis in Software Engineering and Management

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Cover:
The cover image shows the actual airframe that was transformed into a simulator based on requirements elicited during this thesis work.

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***Abstract*—Different requirements elicitation techniques have been researched in the context of their applicability with children, mainly within the field of Human-Computer-Interaction. These techniques have not yet been compared in regard to their compatibility with children within the context of Requirements Engineering.**

The purpose of this case study is to compare five different techniques for eliciting requirements from children, taking into consideration the effectiveness and efficiency of each technique. These five techniques are Interviews, Questionnaires, Storyboarding, Observations and Focus Groups. The context of the case study is the development of a flight simulator at the military aviation museum Aeroseum in Gothenburg, Sweden.

The different techniques will be used to elicit requirements from children in regard to the simulator. These resulting requirements will be taken into consideration in the design and development of the new simulator.

We compared the efficiency and effectiveness of these techniques by looking at the number and type of requirements discovered, participant satisfaction, resources required, and how the discovered requirements were spread throughout domain specific categories.

We observed notable differences between the techniques in the measured areas, with each technique having its own strengths and weaknesses. The performance of the techniques depends heavily on the social aptitude of the participants and their readiness to participate and comply with the technique at hand.

As a result of this research, we present a set of guidelines that aims to aid the industry in developing more child-friendly applications and systems. We also hope that this work will be of benefit to the research community and highlight the need for further research within this topic.

***Index Terms*—Requirements engineering, Requirements elicitation, Children, Questionnaires, Interviews, Storyboarding, Focus Groups, Observations**

I. Introduction

A. Problem Domain and Motivation

This thesis is a part of the ViggenGruppen simulator project, in which a 32 year old SAAB JA37 Viggen fighter jet will be converted into a flight simulator. The simulator will be operated at Aeroseum, an aviation museum located in the north of Gothenburg, Sweden. There are three pre-existing Viggen simulators at Aeroseum which are either outdated or have limited features. Aeroseum attracts a wide audience and the simulators are a popular attraction, especially with younger visitors. None of the pre-existing simulators were designed with the needs of those younger visitors in mind, but instead followed a "one-size-fits-all" approach.

Our role is to elicit requirements from children and take them into account during the simulator development. In practice, these requirements will need to be balanced in regard to Aeroseum's desired level of realism for the simulator. The actual implementation will not be evaluated in the scope of this thesis.

Eliciting requirements from children can pose a challenge due to the different stages of mental maturity and difference in communication skills of the target audience. As such, certain techniques for requirements elicitation may be more suitable than others for use with children. In this study, several elicitation techniques will be compared.

To keep the results of this work more focused, we decided to target a specific age range of children. The age range nine to twelve was focused on, as this age demographic is common at Aeroseum. Furthermore, children of this age range are frequent users of technology [1].

B. Research Goal & Research Questions

The goal of this case study is to present a comparison of requirements elicitation techniques. This comparison will produce both quantitative and qualitative data, which will be used to determine which technique, if any, might be more suitable for younger users. More specifically, we aim to compare the efficiency and effectiveness of these techniques which may aid the industry at large in developing more child-friendly and child-adjusted applications and systems in the growing market of products that target children as their customers [1].

The elicitation techniques considered are:

- Focus Groups
- Interviews
- Storyboarding
- Questionnaires
- Observations

These techniques were chosen because they are well-documented and commonly used with both adults [2]–[5] and

children [6]–[9] and are considered by some to be among the basic techniques of requirements elicitation [4]. However, there is no research explicitly comparing their effectiveness when used with children. See Section II-C for definitions of terms used within this study such as technique, requirement, and child.

Main Research Question: How do the considered elicitation techniques compare in terms of effectiveness and efficiency when used with children?

RQ1: Which of the considered elicitation techniques performs better in terms of effectiveness?

We define effectiveness as:

- The amount of requirements elicited.
- The usefulness of requirements elicited, as rated by a domain expert.
- The amount of unique requirements elicited from each technique compared to the others.
- The amount of functional vs. non-functional requirements elicited from each technique compared to the others.
- The amount of different domain-specific categories the requirements fall into (e.g. audio, gameplay, flight controls etc). This can be used as a basis for judging whether any technique gathers a wider spectrum of requirement types, and if any technique fails at eliciting certain types of requirements.
- The level of participant satisfaction for each technique, based on the researchers' impressions. The reason this is included in effectiveness is that the participants need to enjoy participating in order to be motivated to produce a good overall result.

RQ2: Which of the considered elicitation techniques performs better in terms of efficiency?

We define efficiency as:

- The effort required before (i.e. when preparing the instruments and recruiting children as participants), during (i.e. when conducting sessions) and after using the technique (i.e. when discovering requirements) in relation to the amount of requirements elicited. Effort will be measured in person hours.
- The resources required before, during and after the technique in relation to the amount of requirements elicited. This includes any and all materials used for the technique, the amount of participants and the time invested by them or their guardians.

C. Contribution

Our research will contribute to the existing body of literature by evaluating efficiency and effectiveness of the techniques, where there seems to be a gap in research regarding Requirements Engineering (RE) with children.

Our goal is to provide a concrete comparison of different techniques supported with evidence. We hope that this research can start a wider discussion on requirements elicitation from children within the Requirements Engineering community, so that further research may be encouraged.

The current literature on requirements elicitation with children exists mostly in the field of HCI (Human-Computer Interaction). Different techniques, such as Interviews and Storyboarding, are often combined in different elicitation methods. However, the efficiency (defined above, e.g. time consumption in relation to the number of requirements gathered) and effectiveness (defined above, e.g. the usefulness of requirements elicited) of those techniques and methods are usually only discussed briefly [6], [10], [11], if at all, and precise Figures regarding the effort and resources needed for using the techniques and methods are hard to find.

Furthermore, we aim to develop guidelines for how to select elicitation techniques for different situations, aiding developers and analysts that are interested in eliciting children's requirements.

Finally, a SAAB JA37 Viggen simulator will be built and developed partly based on the requirements elicited. Due to time constraints, this simulator will not be evaluated as a part of this thesis.

II. Background and Related Work

A. Background

A number of HCI community papers have used or described the techniques considered for this thesis project, which are Questionnaires [6], [8], Interviews [6], Observations [7], Focus Groups [7] and Storyboarding [9]. Those will be of significant relevance. As discussed further above, the difference in our approach is that we will compare different techniques, which includes measuring the output of each technique as well as resources and effort needed in higher detail than frequently presented.

Different papers related to the RE community discuss these techniques as well. Zowghi and Coulin [3] compare different techniques in regard to their usability in certain requirements elicitation activities and which of them may be used alongside others. Additionally, they lay out techniques that can be used as an alternative to other ones. Coughlan and Macredie [12] describe techniques as "customer-developer links" and compare their level of communication. Goguen and Linde [2] compare different techniques and take issues related to social interaction into account. Other papers, such as [13], define models for selecting the proper techniques when conducting requirements elicitation. Still, none of these focus specifically on children.

Finally, this thesis will rely on definitions and methods defined in the literature, as well as lessons learned and best practices. As an example, [14] is an extensive paper on surveys overall, though not specifically for children.

B. Related Work

Existing research within the HCI field regarding requirements elicitation from children has focused on different specific age ranges (e.g. age 2 - 3 [10], adolescents [7], teenagers [15]), contexts (e.g. mobile games [10], exergames [7], play by learning [9], web interfaces [11]), elicitation techniques (e.g. computer-aided Storyboarding [9], Drawings

[11], Observations [7], Questionnaires [7] and Primed Design Activities, preparing information introducing the problem to the children before involving them in the design [8]) and methods combining different techniques [6].

Other research has focused on classifying and explaining different levels of involvement in the design process [16], [17], as well as classification of designed features (e.g. the PLU, or Play-Learner-User model [10]).

In the RE field, similar techniques and methods are commonly discussed (as in [2]–[4]) in various contexts, but we have not yet encountered any published RE research which investigates the eligibility of these techniques and methods when used with children.

RE is an "established and recognized" part within Software Engineering [3]. RE concerns itself with the elicitation of requirements, a very complex process using different techniques, which are often selected depending on factors such as time and costs. Most RE techniques are derived from other fields of science such as social science (e.g. [18]), as well as practical experience [3]. These techniques include Interviews, Questionnaires, Observations and Scenarios [3].

Different approaches exist while designing systems: more rationalistic design approaches, where the focus lies on technical aspects and functional requirements of a system, in contrast to more user-centered design approaches that focus on learning and understanding the needs of the users [12]. It has been found that these more user-centered design approaches can lead to more successful projects compared to the more rationalistic approaches [12]. This thesis will focus on these user-centered techniques.

C. Terminology

Children: We aimed to have children aged between nine and twelve in our elicitation sessions. During our elicitation sessions, we made exceptions of +/- one year due to constraints discussed in Section V-E.

(Requirements Elicitation) Technique: We agree with the definition of a requirements elicitation technique as defined by Hickey and Davis: "A documented series of steps along with rules for their performance and criteria for verifying completion. A technique usually applies to a single process in a process model. Sometimes includes a notation and/or a tool" [13].

(Requirements Elicitation) Method: We define a requirements elicitation method as being a large, structured effort, possibly including several requirements elicitation techniques.

Requirement: In this study, requirements will be recorded in the form of user stories, using the common template "As a <type of user>, I want <some goal> so that <some reason>" [19]. Greater emphasis will be put on the goal part rather than the reason, since that describes what the system should do or what properties it should have, as opposed to why. Exploring the reasons for why a child wants a certain feature in more depth is outside the scope of this thesis.

Functional Requirement: We share Sommerville's definition of functional requirements: "These are statements of services the system should provide, how the system should react to particular inputs, and how the system should behave in particular situations" [20].

Non-Functional Requirement: We also share Sommerville's definition of non-functional requirements: "Non-functional requirements [...] are requirements that are not directly concerned with the specific services delivered by the system to its users. They may relate to emergent system properties such as reliability, response time, and store occupancy" [20].

Distinct Requirements and **Duplicates**: When eliciting requirements during several sessions, the same (or very similar) requirement may be generated more than once. The number of different requirements, not including such duplicates, is labelled distinct requirements.

Unique Requirement: When using this term, we refer to distinct requirements that were generated exclusively by a single technique, and not by the other techniques.

Questionnaires: Questionnaires are one of the many techniques used when eliciting requirements from adults, allowing researchers "to collect information from a group of people by sampling individuals from a large population" [14]. A questionnaire poses a number of structured questions that either ask for fixed alternatives or can be answered in a more qualitative manner. Questionnaires can be conducted using a number of mediums such as paper or computers. Our questionnaires were conducted on paper.

Interviews: Interviews are a traditional technique to elicit requirements [3]. They are also a common research method for getting information from children [18]. Interviews can either be conducted with the children themselves or people related to them, such as parents or teachers. Since our research revolves around eliciting requirements from children, it was natural to interview the children directly. Semi-structured interviews were used to allow the children to elaborate and develop their own ideas [18].

Storyboarding: A group activity where the participants collaborate to create a set of drawings illustrating a sequence of events. Traditionally used in the motion picture and advertisement industry [21], Storyboarding has become common practice in the HCI community [22]. Different variations of this technique exist that aim to be specifically child-friendly (e.g. Comicboarding [23] and ChiCo [9]).

Focus Groups: Focus Groups are a more traditional qualitative technique where a group of several participants are supposed to answer questions in regard to a certain topic [24]. Besides its use within the domain of Software Engineering [6], Focus Groups are common within other fields such as nursing [25] and sociology [26].

Observations: Observations are a widely-used ethnographic technique [3]. They have been used with children in social science to get a more in-depth understanding of their experiences and reactions, especially in the younger age ranges where the children are usually not very articulate [27]. Often, Observations are used to complement Interviews or other techniques [3] [27]. Besides being difficult to analyze, the

results can be influenced by the participants acting differently than they usually do in a purely natural environment while being watched [3].

III. Methodology

We compared a set of elicitation techniques. In the following subsections, the execution of elicitation sessions using each technique is described. Pilot sessions were conducted before the main elicitation sessions where applicable. The data from the pilot sessions were used exclusively to improve the material for each main session.

A. Goals

Working with children can potentially achieve unexpected and useful results [6]. A set of goals regarding which type of information to aim to elicit was needed in order to provide a common foundation for creating the material (such as interview guides) for each session. Otherwise, the material would be too varying and have the inherent risk of leading to a bias in which type of information is elicited in each session.

- **G1: Level of enjoyment**, either while using the legacy simulators or (for the children that didn't fly the legacy simulators before the elicitation session) what is required for a simulator to be enjoyable. Includes any motivation or reasons for the above.
- **G2: Any problems that take or could take away from the experience**, either with how the legacy simulators work, e.g. bugs or physical defects, or what kind of problems could cause a simulator to be less enjoyable or comfortable.
- **G3: Learning**, how easy is it to understand how to use the legacy simulators? Are certain features or controls especially hard? What kind of tools or instructions could help to learn how to use a simulator?
- **G4: Information on different flight scenarios**, such as taking off, landing and flying/navigating in general. How is the experience during e.g. takeoff? What is challenging in each scenario? For the Storyboarding sessions, which in our study were not prefaced with using the legacy simulators, other open ended questions around how such a scenario could play out are asked.
- **G5: How comfortable the experience is**, or how to make a comfortable experience. This could contain anything from stress levels to ergonomics.
- **G6: How immersive/realistic the experience is**, or how to make a realistic experience.

B. Questionnaires

Our questionnaire was developed iteratively. An initial version was created following guidelines and best practices as described in [14]. However, as certain considerations have to be taken in order to ensure that the questionnaires are suitable for children, we decided to refine them using guidelines suggested by [28] and [29] where it is noted that retrospective, ambiguous, double-barrelled and complex questions should be avoided. As such, the initial questionnaire was refined according to those papers.

The pilot questionnaire was then reviewed by two senior researchers, after which a few minor changes were made. Among these changes were changes to the smiley-based Likert-scale which previously consisted of five uncolored smiley-faces. The refined version used three smiley-faces which were color coded depending on their implication. Fig. 1 shows a question using this scale. To avoid *satisficing* [28], the order of questions was altered by moving more administrative questions to the beginning of the questionnaire which made them more unlikely to be answered in an incorrect, albeit convenient way for the participant. Finally, some questions were simplified (e.g. replaced words such as "elaborate" with a more child friendly "tell us").

Fig. 1. Example question using color-coded smileys

Furthermore, the questionnaire pilot was evaluated using the 'think-aloud' technique [28] in which the subject articulates his or her thoughts out loud while filling in the questionnaire. Using this technique, we found that a number of questions could be further refined and clarified. As an example, one of the respondents answered "I've never flown a real airplane" when asked to compare their experience to what they imagine what flying a real airplane might feel like. These thoughts were used to refine the questionnaire further to produce a final version as outlined in Appendix A, Figure 9.

The questionnaire was conducted using a simple random sampling approach [14] by having questionnaires as well as an information poster displayed near the simulator area. The questionnaires were either handed out to children after flying the simulator or left in a visible area for them to retrieve. The actual questionnaire was printed as a double-sided A4 paper in landscape orientation with colors.

C. Interviews

The initial outline for our interview guide was constructed based on guidelines suggested in [30] and largely influenced by the questionnaire, with the added possibility of more open-ended answers. Furthermore, open-ended questions such as "What else did you try to do?" were added in the middle section of the interview. Afterwards, the interview guide was refined using [18] in order to ensure suitability for children.

Fellow researchers offered feedback on the interview guide which allowed us to further condense and simplify it. A pilot was then conducted, allowing us to gauge our interview procedures and prepare possible follow-up questions. It also outlined further beneficial changes to the wording of the questions. The final interview guide can be found in Appendix A, Figure 10.

The interviews were semi-strucutred and conducted in Swedish with individual children after their use of one of

the legacy simulators. The interview sessions were captured in notes.

D. Storyboarding

An initial storyboarding guide was developed following recommendations by [22] and was refined to be more child-friendly based on guidelines presented in [23]. A senior researcher reviewed the guide and gave feedback.

The final guide (Appendix A, Figure 11) featured five scenarios that were created in consideration of our predefined goals. We applied scaffolding [23] throughout those scenarios, where more support is given to the participants initially when they are introduced to a new technique. That meant that more information was provided in the first two scenarios in order to support the participants when they were being acquainted with the technique and process. Later scenarios did not include the same level of support and were more concise. Additionally, a picture of the plane, the cockpit and a movie storyboard was shown to the participants, to give them a broader understanding of the topic and the technique.

As Storyboarding relies heavily on the imagination of the participants, it can be argued that letting them use the legacy simulators before creating those storyboards would bias the participants too much, limiting them from thinking ”outside the box” in relation to those simulators. Therefore, all sessions were conducted off-location, without the children first using any of the legacy simulators. This also gave the opportunity to compare the results of an off-location technique to those techniques conducted on location, as well as to see if relevant requirements can be elicited without having a legacy system or prototype at hand. Ideally, with more time and resources, we would have been able to isolate and compare these two factors separately (this will be further discussed in the Section V).

Two sessions were conducted, each with three children between eleven and twelve. The participants were selected using a snowballing sampling approach [14]. Storyboarding required a greater time investment by its participants and had to be pre-arranged with parents of eligible participants. Because of the effort required by the participants, a symbolic reward in the form of a snack was served after each session. Some of the parents were known to the researchers beforehand and helped to recruit more children. Each storyboarding session was conducted by a single researcher. This is a possible threat to validity that will be further discussed in Section V-D.

For analyzing the data, the final storyboard drawings on either A2 or A3 paper were collected and saved by the researcher, who made notes throughout the session.

E. Focus Groups

It is important to plan focus group sessions ahead of time [25]. Therefore, our focus group sessions were planned after recruiting participants from a local school. This gave us their age, number and time constraints which we could utilize when planning our sessions.

While Hannay et al. [24] recommend bigger groups of six to twelve children in order to keep a good balance between variety of viewpoints and each participant’s opportunity to speak, other sources such as [25] say that the ideal group size depends on the age of the children.

Furthermore, these resources do also not agree on the length of each focus group session. Morgan et al. [26] recommend to have a session last for 40 minutes with a break in the middle while Gibson [25] recommends sessions between 45 and 90 minutes. Even longer sessions between 30 minutes and 2 hours are recommended by [24].

As the participating school class had time constraints of their own, it was decided to conduct two Focus Groups of five children each in single 20 minute sessions.

A focus group session guide was developed based on recommendations by [24] and [25]. As recommended by [25], a *standard statement* was prepared that established common ground between the groups. The session guide was reviewed by a senior researcher and a media-industry expert experienced in conducting focus groups. We were not able to conduct a pilot session, but had previously tried our interview questions with a group of children with good results. The general theme of the questions in our focus group session guide was similar or overlapping with our interview guide. The final focus groups guide can be found in Appendix A, Figure 13.

Following the recommendation from Hannay et al. [24], the focus group sessions were conducted by two researchers, with one responsible for moderating the interview while the other kept notes. Furthermore, audio of the sessions was recorded after the participants gave their permission.

F. Observations

An observation checklist was prepared prior to conducting the observations. As with the other techniques, we considered our predefined goals when preparing this material. The checklist was designed to be printed on one A4 sheet of paper, including space for the observer to take notes. The observation sessions were designed to be conducted with individual children, each using one of the legacy simulators for 20 minutes. Time constraints by the participants was a leading factor in limiting the session time.

It could not be expected that the participants would be able to explore our goal-defined scenarios within the given time-frame. It was therefore decided that the first half of the observation sessions would be passive, and the second half could proceed with giving the children a specific task to solve, in the cases where the children had acquired an acceptable level of proficiency. We made the assumption that this would enable us to get more information on how the child handles certain challenges in a more condensed time. A task could be finding an airport, attempting to articulate their geographical location (the simulation takes place in the local Gothenburg area which is familiar to them), or to try to land. All participants were tasked with the same set of scenarios.

Since Observations are mostly passive (see discussion above), no pilot was conducted. Nevertheless, a senior researcher provided feedback on the observation guide. No significant changes were made to the observation checklist.

The finished checklist can be found in Appendix A, Figure 14.

Video recordings could possibly contain more information than the observer can note during the actual session, but due to possible ethical considerations, we decided to not record any video footage.

The participants of the observation session were all from one school class, and were born in 2005 (making them age 11-12). Each observation was made by one researcher.

G. Discovery of Requirements

In order to avoid bias, the artifacts generated during the elicitation sessions were reviewed individually by each researcher. Individual requirements were then extracted from these reviews which were later examined and reviewed by the team and merged into a common list of requirements. Each researcher started their individual extraction process with artifacts from a different technique than the others in order to avoid a common learning bias among all three researchers.

The resulting requirements were merged into a common list by comparing individual sets for each session within a certain technique. The wording of the requirements were discussed in detail.

For reoccurring requirements within the merged list, both their total number of occurrences as well as the number of occurrences within each technique were noted.

Additionally, the requirements were labelled as functional or non-functional requirements as well as categorized into different domain-specific categories depending on which part of the simulator system they related to. The categories were discovered from the requirements and are listed in Section IV-A.

To verify that the requirements in the common list were valid and well formed, they were reviewed by a requirements engineering expert.

Finally, the list was reviewed by an expert within the simulator domain, who evaluated the requirements in terms of usefulness. This data was used when comparing the different techniques (see Sections IV & V).

H. Participant Satisfaction

Our instruments included questions regarding the participant satisfaction level. However, we quickly realized that there would be a discrepancy between the participants' answers due to their enjoyment and our own impression. It can be hard to give an honest answer to a question of this nature, especially if the participant is inclined to give a negative grade. Therefore, we decided to put more emphasis on our own impressions.

After conducting all elicitation sessions, each researcher rated their total impression of the participants' satisfaction during each technique using a scale of 1 to 5. The average rating from all three researchers is used as a value for the participant satisfaction in the following sections.

IV. Results

Our data collection was conducted over a number of sessions in April 2017. The data collected is shown in Table I. Observations and Focus Groups were conducted exclusively using participants from a local school as they required a greater time investment from their participants, while Interviews and Questionnaires were conducted both with the school participants as well as random eligible visitors at the museum (simple random sampling [14]). Storyboarding was conducted off-site with eligible participants (accidental/convenience sampling [14]). All requirements and their occurrences within each technique are listed in Appendix B, Tables XXIX and XXX. Table XXVIII shows a detailed breakdown of the effort invested by the researchers and participants for each technique.

TABLE I
Number of participants

Technique	Number of participants, group configurations	Age range	Sample
Questionnaires	13, individual	9-13	Museum visitors and school children
Interviews	12, individual	8-13	Museum visitors and school children
Observations	13, individual	12-13	School children
Focus Groups	2 groups of 5	12-13	School children
Storyboarding	2 groups of 3	11-12	Snowball sample

A. Categories

Each requirement was labelled as belonging to one or two of the following categories. The categories were discovered from the requirements.

- **Audio:** Requirements related to sound effects and how they are presented.
- **Child Friendliness:** Requirements related to the fact that children are a part of the target audience, e.g. that there needs to be some simplification regarding how some parts of the system work.
- **Display/Graphics:** Requirements related to the visual output of the simulator and how it is presented.
- **Flight Controls:** Requirements related to the controls in the simulator such as the joystick, throttle and other switches and levers.
- **Flying:** Requirements related to flying the airplane in the simulator world.
- **Gameplay:** Requirements related to the game aspect of the simulator. Anything present that makes the experience more challenging or exciting in a game-related way.
- **Help/Reminder:** Requirements related to helping the user, e.g. instructions, helpful labels or help messages.
- **Navigation:** Requirements related to navigation during flight. This may concern for example navigation tools (e.g. a map or compass) or landmarks.
- **Physical Environment:** Requirements related to the physical environment of the simulator (e.g. the cockpit and the surrounding environment) as opposed to the simulator world.

- **Realism/Immersion:** Requirements related to the realism of the simulation, such as physical feedback and accurate instruments.
- **Situation:** Requirements related to the situation in the simulator world, such as where the user starts, what time of day it is and how the weather is.

To see the which user stories were considered belonging to each category, see Appendix B, Tables XXIX and XXX.

B. Questionnaires

We conducted this technique over a period of one month and received answered questionnaires from 13 children that were in our target age range. Even though it was mentioned that the questionnaires were intended for children, we received some answers from adults. These were ignored. An example of an answered questionnaire can be seen in Figure 2. Detailed answers can be found in Appendix B, Tables XVII and XVIII.

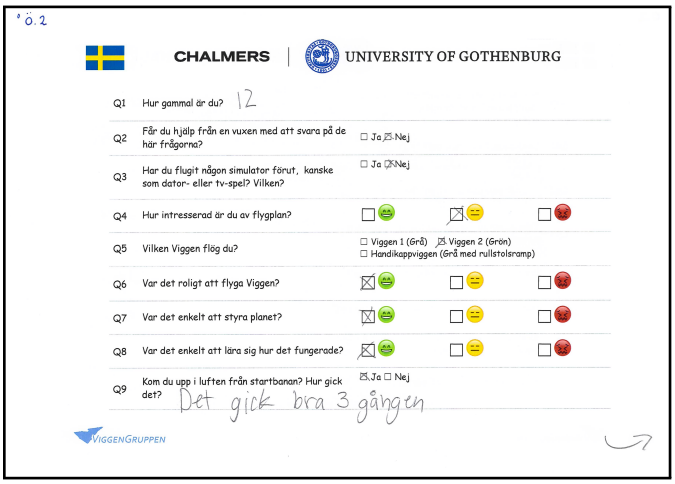

Fig. 2. Sample questionnaire reply, page 1 of 2.

Based on the answered questionnaires, 13 requirements were discovered, of which 6 were functional, 4 were non-functional, and 3 were considered both/either[1]. Within the 13 requirements, there were 3 duplicates, which means 10 distinct requirements (see Section II-C for definitions of these terms). Table II shows the distribution of functional and non-functional requirements for this technique.

The most common categories were Realism/Immersion and Flight Controls. This was the only technique that did not result in any requirements in the Display/Graphics category. Table III shows the amount of requirements included in each category for Questionnaires.

The requirements from this technique held an average usefulness rating of 3.1 (on a scale from 1 to 5), according to our domain expert.

[1]Requirements that could be solved by either a functional (e.g. adding a feature) or non-functional (e.g. improving the quality) solution are labelled both/either.

TABLE II
QUESTIONNAIRES: FUNCTIONAL VS NON-FUNCTIONAL REQUIREMENTS

Type	Distinct requirements	Ratio	Duplicates
Functional	5	50%	1
Non-functional	4	40%	0
Both/either	1	10%	2

TABLE III
QUESTIONNAIRES: CATEGORIES

Category	Distinct requirements	Ratio	Duplicates
Audio	0	0%	0
Children Friendliness	2	11.8%	0
Display/Graphics	0	0%	0
Flight Controls	3	17.6%	0
Flying	2	11.8%	0
Gameplay	2	11.8%	1
Help/Reminder	2	11.8%	2
Navigation	1	5.9%	2
Physical Environment	1	5.9%	0
Realism/Immersion	3	17.6%	1
Situation	1	5.9%	0

The time invested in creating the questionnaire was 25 person hours. This was relatively long compared to the other techniques, which was probably caused by it being the first instrument created (for discussion see Section V-D). On an individual scale, each questionnaire gave on average 0.77 distinct requirements and took an average of 3 minutes and 12 seconds to respond to (based on the questionnaires where the participants specified the time spent), in addition to the 15 minutes of flying.

Discovering requirements from the answered questionnaires took 6.9 person hours[2], which results in 0.7 person hours per distinct requirement. Including the creation of the questionnaire and the time to conduct the flying and questionnaires, the total effort by the researchers on elicitation and discovery was 3.6 person hours per distinct requirement.

The resources used for conducting Questionnaires were the printed questionnaires, pens, and the legacy simulators which were used by the participants prior to answering the questionnaires.

C. Interviews

In total, 12 interviews were conducted, of which 10 were usable (the rest being outside our age range). All three researchers participated during those interview session. Detailed interview notes can be found in Appendix B, Tables XIX, XX, XXI and XXII.

Based on the interview notes, 39 requirements were discovered, of which 7 were functional, 24 were non-functional, and 8 were considered both/either. Within the 39 requirements, there were 23 duplicates, which means 16 distinct requirements. Table IV shows the distribution of functional and non-functional requirements for Interviews.

The most common categories were Realism/Immersion and Navigation. Interviews were the only technique that did not

[2]The discovery process is outlined in section III-G.

result in any requirements in the Situation category. Table V shows the amount of requirements included in each category for this technique.

According to the domain expert, the requirements from Interviews held an average usefulness rating of 3.38 (on a scale from 1 to 5).

TABLE IV
INTERVIEWS: FUNCTIONAL VS NON-FUNCTIONAL REQUIREMENTS

Type	Distinct requirements	Ratio	Duplicates
Functional	5	31.3%	2
Non-functional	10	62.5%	14
Both/either	1	6.3%	7

TABLE V
INTERVIEWS: CATEGORIES

Category	Distinct requirements	Ratio	Duplicates
Audio	0	0%	0
Children Friendliness	1	3.2%	2
Display/Graphics	4	12.9%	5
Flight Controls	1	3.2%	2
Flying	4	12.9%	7
Gameplay	2	6.5%	6
Help/Reminder	4	12.9%	8
Navigation	5	16.1%	9
Physical Environment	3	9.7%	0
Realism/Immersion	7	22.6%	6
Situation	0	0%	0

The time invested in creating the interview guide was 10.5 person hours. On an individual scale, each interview gave on average 1.33 distinct requirements, and took an average of 7 minutes and 23 seconds to participate in, in addition to the 15 minutes of flying.

Discovering requirements from the interview notes took 8.4 person hours, which results in 0.5 person hours per distinct requirement. Including the creation of the interview guide and the time to conduct the flying and Interviews, the total effort spent by the researchers on elicitation and discovery was 1.5 person hours per distinct requirement.

The resources used for conducting the interviews was a computer to follow the interview guide and to take notes, as well as the legacy simulators which were used by the participants prior to the interview.

D. Storyboarding

Storyboarding was conducted using two groups with ages ranging from 11 to 12. Participants were asked to illustrate scenarios as they interpreted them in a storyboard format. Figure 3 shows an example of an illustrated Storyboarding scenario. Detailed notes on the storyboarding sessions can be found in Appendix B, Tables XXIII and XXIV.

Based on the storyboarding drawings, 11 requirements were discovered, of which 9 were functional, 2 were non-functional, and none were considered both/either. Within the 11 requirements, there was 1 duplicate, which means 10 distinct requirements. Table VI shows the distribution of functional and non-functional requirements for this technique.

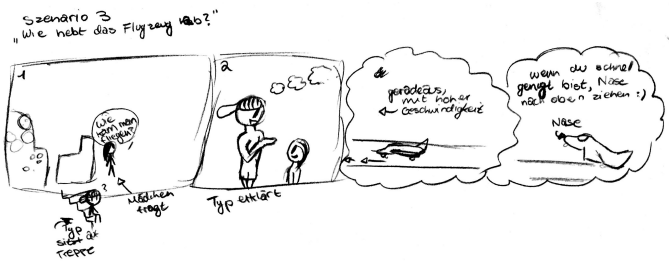

Fig. 3. Sample Storyboarding scenario.

The most common category was Gameplay. Storyboarding was the only technique that did not result in any requirements in the Flight Controls category. Table VII shows the amount of requirements included in each category for Storyboarding.

The requirements from Storyboarding held an average usefulness rating of 3.3 (on a scale from 1 to 5), according to our domain expert.

TABLE VI
STORYBOARDING: FUNCTIONAL VS NON-FUNCTIONAL REQUIREMENTS

Type	Distinct requirements	Ratio	Duplicates
Functional	8	80%	1
Non-functional	2	20%	0
Both/either	0	0%	0

TABLE VII
STORYBOARDING: CATEGORIES

Category	Distinct requirements	Ratio	Duplicates
Audio	0	0%	0
Children Friendliness	2	11.8%	0
Display/Graphics	1	5.9%	1
Flight Controls	0	0%	0
Flying	2	11.8%	0
Gameplay	4	23.5%	0
Help/Reminder	2	11.8%	0
Navigation	1	5.9%	1
Physical Environment	2	11.8%	0
Realism/Immersion	2	11.8%	0
Situation	1	5.9%	0

The time invested in creating the storyboarding guide was 12 person hours. Each storyboarding session gave an average of 5 distinct requirements, and took 70 minutes on average to participate in for the 3-person groups.

Discovering requirements from the interview notes took 2.7 person hours, which results in 0.3 person hours per distinct requirement. Including the creation of the storyboarding guide and the time to conduct the storyboarding session, the total effort spent by the researchers on elicitation and discovery was 1.7 person hours per distinct requirement.

The resources required for conducting the storyboarding sessions were a computer used to follow the storyboarding guide and to take notes, A3 or A2 paper for the participants to draw on, pens, and a paper with example pictures.

As discussed in Section III-D, to avoid biasing the children's view of what a simulator is and to try a technique without

being dependent on the legacy simulators, these sessions were conducted without the children first using the legacy simulators.

E. Focus Groups

Focus Groups were conducted with two groups, wherein each group had five participants. One researcher moderated the discussion while another one took notes. Each session lasted 15 minutes and was recorded on audio. Detailed transcripts of those audio recordings can be found in Appendix B, Figures 17 and 18

Based on the focus groups transcriptions, 21 requirements were discovered, of which 13 were functional, 7 were non-functional, and 1 was considered both/either. Within the 21 requirements, there were 5 duplicates, which means 16 distinct requirements. Table VIII shows the distribution of functional and non-functional requirements for Focus Groups.

The most common category was Help/Reminder. Focus Groups was the only technique that resulted in requirements for each category. Table IX shows the amount of requirements included in each category for this technique.

According to our domain expert, the requirements from Focus Groups held an average usefulness rating of 3.5 (on a scale from 1 to 5).

TABLE VIII
FOCUS GROUPS: FUNCTIONAL VS NON-FUNCTIONAL REQUIREMENTS

Type	Distinct requirements	Ratio	Duplicates
Functional	10	62.5%	3
Non-functional	5	31.3%	2
Both/either	1	6.3%	0

TABLE IX
FOCUS GROUPS: CATEGORIES

Category	Distinct requirements	Ratio	Duplicates
Audio	1	3.2%	0
Children Friendliness	2	6.5%	1
Display/Graphics	4	12.9%	1
Flight Controls	2	6.5%	2
Flying	4	12.9%	1
Gameplay	1	3.2%	0
Help/Reminder	7	22.6%	2
Navigation	3	9.7%	0
Physical Environment	3	9.7%	1
Realism/Immersion	3	9.7%	2
Situation	1	3.2%	0

The time invested in creating the focus group guide was 12 person hours. Each focus group session gave on average 8 distinct requirements, and took the groups an average of 15 minutes to participate in, in addition to the 15 minutes of flying.

Discovering requirements from the focus group transcriptions took 8.1 person hours, which results in 0.5 person hours per distinct requirement. Including the creation of the Focus Groups guide and the time to conduct the flying and Focus Groups, the total effort spent by the researchers on elicitation and discovery was 1.5 person hours per distinct requirement.

The resources used for conducting the focus group sessions were a computer to follow the focus group guide and to take notes, an audio recording device, as well as the legacy simulators which were used by the participants prior to the session.

F. Observations

Observations were conducted individually. Thirteen observation sessions took place. Each participant was observed while flying for 15 minutes. During the latter half of the observation session, the participants were asked to finish predetermined tasks. Detailed notes of the observation sessions can be found in Appendix B, Tables XXV, XXVI and XXVII.

Based on the observation notes, 45 requirements were discovered, of which 23 were functional, 19 were non-functional, and 3 were considered both/either. Within the 45 requirements, there were 25 duplicates, which means 20 distinct requirements. Table X shows the distribution of functional and non-functional requirements for Observations.

The most common category was Help/Reminder. Table XI shows the amount of requirements included in each category for this technique.

According to the domain expert, the requirements from Observations held an average usefulness rating of 3.35 (on a scale from 1 to 5).

TABLE X
OBSERVATIONS: FUNCTIONAL VS NON-FUNCTIONAL REQUIREMENTS

Type	Distinct requirements	Ratio	Duplicates
Functional	11	55%	12
Non-functional	8	40%	11
Both/either	1	5%	2

TABLE XI
OBSERVATIONS: CATEGORIES

Category	Distinct requirements	Ratio	Duplicates
Audio	0	0%	0
Children Friendliness	1	2.9%	7
Display/Graphics	2	5.9%	1
Flight Controls	5	14.7%	14
Flying	4	11.8%	4
Gameplay	1	2.9%	0
Help/Reminder	10	29.4%	12
Navigation	3	8.8%	2
Physical Environment	5	14.7%	1
Realism/Immersion	1	2.9%	0
Situation	2	5.9%	1

The time invested in creating the observation guide was 4 person hours. Each observation session gave on average 1.54 distinct requirements, and took the participants 15 minutes to participate in (flying time while being observed).

Discovering requirements from the observation notes took 4 person hours, which results in 0.4 person hours per distinct requirement. Including the creation of the observation guide and the time to conduct the observation sessions, the total effort spent by the researchers on elicitation and discovery was 0.8 person hours per distinct requirement.

The resources used for conducting the observation sessions were the printed observation checklist, and the legacy simulators.

G. Comparison

This subsection compares results among each technique in relation to the research questions.

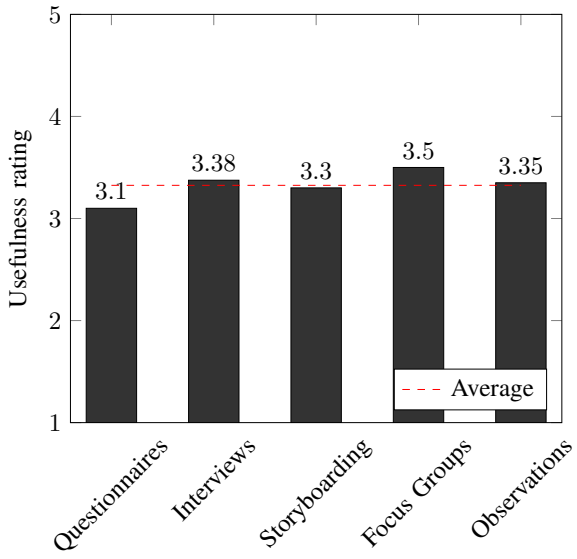

Fig. 4. Average usefulness rating for each technique

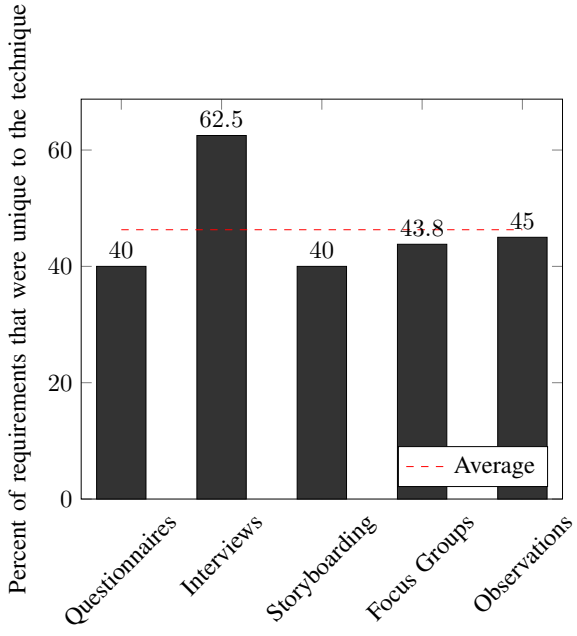

Fig. 5. Unique requirements ratio

1) RQ1 Effectiveness: Here, the results are presented in relation to the different aspects of effectiveness as defined in Section I-B.

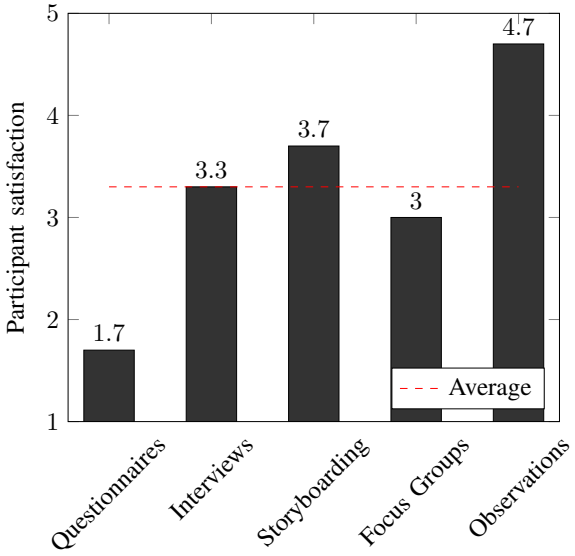

Fig. 6. Participant satisfaction according to researcher impressions

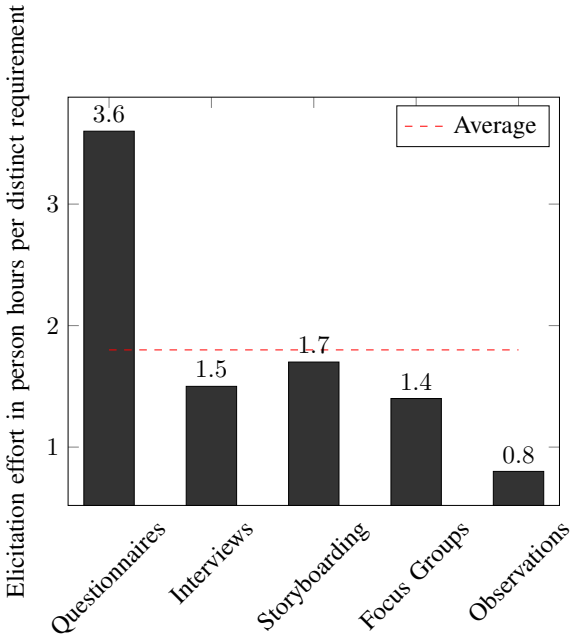

Fig. 7. Elicitation effort per distinct requirement

The amount of requirements elicited: Observations generated the highest amount of requirements (20 distinct requirements). Note that this is not adjusted for the amount of time invested in each technique - see RQ2 for a comparison of efficiency. Interviews and Focus Groups performed well with 16 distinct requirements each. Storyboarding and Questionnaires performed the worst, with each giving 10 distinct requirements. For details, see Table XII.

TABLE XII
EFFORT USED AND REQUIREMENTS ELICITED FOR EACH TECHNIQUE

Data	Questionnaires	Interviews	Storyboarding	Focus Groups	Observations	Average
Total elicitation effort (person hours)*	35.9	23.4	17.0	23.1	15.1	22.9
Total participant effort (person hours)	4.0	4.5	7.0	5.0	3.3	4.7
Total requirements	13	39	11	21	45	25.8
Distinct requirements	10	16	10	16	20	14.4
Participant effort per distinct requirement	0.4	0.3	0.7	0.3	0.2	0.4
Elicitation effort per distinct requirement	3.6	1.5	1.7	1.4	0.8	1.8

*This is the total requirements engineering effort, i.e. it includes the creation of instruments.

TABLE XIII
DISTINCT FUNCTIONAL VS NON-FUNCTIONAL REQUIREMENTS BY TECHNIQUE, RELATIVE

Type	Questionnaires	Interviews	Storyboarding	Focus Groups	Observations	Total
Functional	50.0%	31.3%	80.0%	62.5%	55.0%	54.2%
Non-functional	40.0%	62.5%	20.0%	31.3%	40.0%	40.3%
Both/either	10.0%	6.3%	0.0%	6.3%	5.0%	5.6%

TABLE XIV
FUNCTIONAL VS NON-FUNCTIONAL REQUIREMENTS BY TECHNIQUE

Data	Type	Questionnaires	Interviews	Storyboarding	Focus Groups	Observations	Total
All Requirements	Functional	6	7	9	13	23	58
All Requirements	Both/either	3	8	0	1	3	15
All Requirements	Non-Functional	4	24	2	7	19	56
All Requirements	Sum	13	39	11	21	45	129
Distinct Requirements	Functional	5	5	8	10	11	39
Distinct Requirements	Both/either	1	1	0	1	1	4
Distinct Requirements	Non-Functional	4	10	2	5	8	29
Distinct Requirements	Sum	10	16	10	16	20	72
Unique Requirements	Functional	2	3	3	4	6	18
Unique Requirements	Both/either	0	0	0	0	0	0
Unique Requirements	Non-Functional	2	7	1	3	3	16
Unique Requirements	Sum	4	10	4	7	9	34

TABLE XV
DISTINCT REQUIREMENTS IN EACH CATEGORY BY TECHNIQUE, RELATIVE

Category	Questionnaires	Interviews	Storyboarding	Focus Groups	Observations	Total
Audio	0.0%	0.0%	0.0%	3.2%	0.0%	0.8%
Children Friendliness	11.8%	3.2%	11.8%	6.5%	2.9%	6.2%
Display / Graphics	0.0%	12.9%	5.9%	12.9%	5.9%	8.5%
Flight Controls	17.6%	3.2%	0.0%	6.5%	14.7%	8.5%
Flying	11.8%	12.9%	11.8%	12.9%	11.8%	12.3%
Gameplay	11.8%	6.5%	23.5%	3.2%	2.9%	7.7%
Help / Reminder	11.8%	12.9%	11.8%	22.6%	29.4%	19.2%
Navigation	5.9%	16.1%	5.9%	9.7%	8.8%	10.0%
Physical Environment	5.9%	9.7%	11.8%	9.7%	14.7%	10.8%
Realism / Immersion	17.6%	22.6%	11.8%	9.7%	2.9%	12.3%
Situation	5.9%	0.0%	5.9%	3.2%	5.9%	3.8%

TABLE XVI
REQUIREMENTS UNIQUE TO EACH TECHNIQUE

Data	Questionnaires	Interviews	Storyboarding	Focus Groups	Observations	Average
Distinct requirements	10	16	10	16	20	14.4
Unique requirements	4	10	4	7	9	6.8
Unique requirements ratio	40.0%	62.5%	40.0%	43.75%	45.0%	46.25%

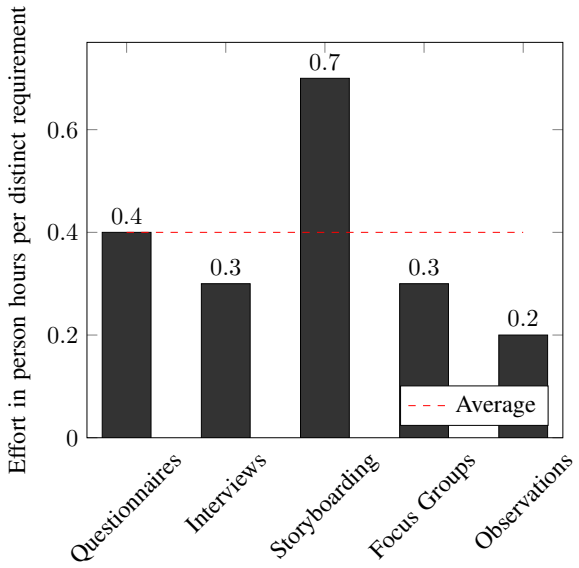

Fig. 8. Participant effort per distinct requirement

The usefulness of requirements elicited, as rated by a domain expert: The average usefulness rating for the requirements elicited from each technique ranges from 3.1 to 3.5, which means there were rather subtle differences in relation to the small samples we have. Focus Groups performed the best followed by Interviews. Storyboarding and Observations were around average. Questionnaires performed the worst. For details, see Figure 4.

The amount of unique of requirements elicited from each technique compared to the others: This comparison will be based on the ratio between the amount of unique requirements and the amount of distinct requirements within each technique. Interviews clearly stood out as the best performing (62.5%), Focus Groups and Observations were slightly below average, with Questionnaires and Storyboarding performing the worst. For further details, see Table XVI and Figure 5.

The amount of functional vs. non-functional requirements elicited from each technique compared to the others: Again, the comparison will be based on relative numbers, i.e. how large the share of the distinct requirements within each technique fell into each category.

The techniques with the largest share of functional requirements were Storyboarding and Focus Groups.

The technique with the largest share of non-functional requirements was Interviews. Storyboarding had the smallest share of non-functional requirements. Questionnaires and Observations were both close to having an equal distribution among functional vs non-functional requirements. For details, see Tables XIII and XIV.

The amount of different domain-specific categories the requirements fall into: Focus Groups was the only technique that generated requirements for all 11 categories, followed by Observations (10 categories), with Questionnaires, Interviews and Storyboarding generating requirements in 9 categories each. Questionnaires gave the most evenly distributed set of requirements in terms of categories. Note however that all categories are not necessarily equally useful, and judging the utility of each category is outside the scope of this work. For details, see Table XV.

The level of participant satisfaction for each technique, based on the researchers' impressions: Observations performed best in terms of participant satisfaction, with a rating of 4.7. Storyboarding (3.7), Interviews (3.3) and Focus Groups (3) were close or equal to the average (3.3). Questionnaires performed the worst with a rating of 1.7.

As discussed in Section III-H these are subjective impressions but should give a basic hint on which techniques the researchers believed were the most appreciated by the participants. For details, see Figure 6.

Summary of RQ1 Results

- Observations had the highest amount of distinct requirements and struck a good balance between functional and non-functional requirements. The usefulness of those requirements were around average. This technique also had the highest participant satisfaction.
- Focus Groups resulted in the highest amount of different types of requirements. It resulted in requirements from all categories, and was the only technique to do so. The requirements elicited had the highest average usefulness rating. The participant satisfaction was slightly below average.
- Interviews had the highest ratio of unique requirements, and performed relatively well in the other aspects such as amount of requirements and usefulness. Interviews brought up mostly non-functional requirements. The participant satisfaction was around average.
- Storyboarding performed comparatively poorly. It brought up mostly functional requirements with a usefulness rating around average. The Gameplay category was populated to a large extent by requirements elicited from Storyboarding sessions. For this technique, participant satisfaction was above average.
- Questionnaires performed comparatively poorly as well. It had a close to equal distribution between functional and non-functional requirements, but a low number of distinct requirements per participant and a lower than average usefulness rating. Additionally, it had the worst participant satisfaction rating.

2) RQ2 Efficiency: Here, the results are presented in relation to the different aspects of efficiency as defined in Section I-B.

The effort required before, during and after using the technique in relation to the amount of requirements elicited:

Observations clearly performed best in this regard, with 0.8 person hours per distinct requirement, followed by Focus Groups (1.4), Interviews (1.5) and Storyboarding (1.7). Questionnaires performed worst with 3.6 person hours per distinct requirement.

For further details on elicitation effort per distinct requirement, see Table XII and Figure 7.

The resources required before, during and after the technique in relation to the amount of requirements elicited. This includes any and all materials used for the technique, the amount of participants and the time invested by them or their guardians: Since most techniques did not require a lot of material resources, the participant effort per distinct requirement will be considered more important when evaluating this aspect.

The participant effort per distinct requirement was lowest for Observations (0.2 person hours) followed by Focus Groups and Interviews (0.3 each). Questionnaires (0.4) and Storyboarding (0.7) performed the worst.

The point where the material resources differed the most between techniques were the legacy simulators, which were used in all techniques except Storyboarding, as described in Section III-D.

For details on the participant effort, see Table XII and Figure 8.

Summary of RQ2 Results

- Observations had the lowest elicitation effort per distinct requirement and the lowest participant effort per distinct requirement.
- Focus Groups performed second best in terms of elicitation effort per distinct requirement, and had a relatively low participant effort per distinct requirement.
- Interviews had a slightly higher elicitation effort per distinct requirement than Focus Groups. The participant effort per distinct requirement was relatively low.
- Storyboarding performed around average in terms of elicitation effort per distinct requirement. Storyboarding required the highest participant effort per distinct requirement.
- Questionnaires performed worst in elicitation effort per distinct requirement. With a higher amount of participants, the effort per distinct requirement could have been lower.

V. Discussion

A. Discussion of Individual Techniques

We discuss the observed results, benefits and challenges of each applied technique.

Questionnaires: The Questionnaires went mostly unanswered if potential participants were not approached and asked to participate in the survey. This was a prevalent issue with the technique, despite the forms being clearly displayed and presented at the simulation area. A greater number of responses might have been recorded if potential participants had an incentive to participate. Focus Groups and Observations had incentives in the form of free flying time, while storyboarding sessions had participation rewards. Interview participants were approached by researchers after flying. These techniques had more respondents within the time frame which we believe to be a direct result of these incentives.

Although the questionnaires offered participants the chance to elaborate further on answers in the form of qualitative data, participants seldom offered further details. This made it difficult to elicit requirements from some of the answers and might have been prevented with a better design and motivation, but this might be an age-related issue as well. Most of the elicited requirements came from qualitative answers.

The elicitation effort per elicited requirement would have been significantly lower with more participants, as the preparation for this technique demanded a greater time investment than the other methods as shown in Appendix B, Table XXVIII.

Interviews: The interviews were semi-structured and conducted in Swedish using an interview guide (see Appendix A, Figure 10) after the participants had flown the legacy simulators. This allowed interviewers to delve deeper into responses and follow up with questions not anticipated in the interview guide. Interviewees were sometimes unable or unwilling to elaborate further on their answers, resulting in a relatively structured outcome as they more or less followed the established interview structure. Even though this can happen with a few participants, the semi-structured approach overall gave satisfying results. This is supported by Prior [31], who describes semi-structured designs as a very useful way of conducting Interviews with children.

Interviewers made an attempt to avoid the image of authority by conducting them in a casual environment and setting. The interviews themselves were conducted in a lighthearted and humorous manner if and where appropriate in order to foster this informal and casual environment. Despite this, a number of respondents elected to provide mostly yes/no answers, as discussed above. Interviewers often dictated answers back to interviewees, which helped them elaborate their answers further. Parents were often present during the Interviews, but never offered any input during the Interviews.

Storyboarding: As discussed in Section III-D, storyboarding sessions were conducted off-location without prior flying of the legacy simulators. This made it necessary to give the children a small hint on what the actual airplane looks like.

Therefore, one picture of its exterior and one of its interior was shown to the participants in a printed format (for the actual guide, see Appendix A, Figure 12). Special care is required when selecting those pictures as they can affect the outcome directly (e.g. a single seat in the cockpit makes it clear that just one person operates the plane as opposed to a commercial airliner with several hundred seats).

The participants in one group became excited when they heard that Storyboarding is a technique that is widely used in the movie industry. This group was very interested in the technique itself and displayed a level of creativity we had not expected. Another group approached the technique with less interest and made a game out of it, often disregarding the scenarios completely. However, despite the difference in creativity and performance between the groups, a similar amount of requirements were elicited from the data gathered.

It is important to note that interruptions during a session may potentially have a direct impact on the outcome of the session. During one scenario, participants were informed by a parent that they would eat pizza after the session. This lead to the results of one scenario being completely related to eating and gave results that were likely not appropriate for a flight simulator (see Scenario 4 in Appendix B, Figure 16).

Maintaining a productive session atmosphere without sacrificing the level of entertainment the participants perceived proved to be challenging, and the balance between distraction and productivity was difficult.

Focus Groups: Focus Groups and Interviews share a number of common characteristics that made the preparation of the Focus Groups simpler and faster after the interview instruments had already been created. It's important to note that this may also have been caused by a certain learning bias among the researchers (see Section V-D).

In opposite to regular Interviews, Focus Groups are group-based interviews. This has the advantage of follow-up answers from different participants and the option of group discussions, but can also be hampered by participants that feel intimidated by others or are not willing to admit to shortcomings (e.g. not being able to land the simulator). Therefore, a healthy group composition is crucial for the success of this technique.

Some participants in our first focus group were shy towards other participants and less comfortable in engaging in discussions, despite being in the same class. This led to fewer elicited requirements from this group compared to the second one which was more willing to engage in discussions. We believe that this issue might have been avoided by ensuring the compatibility of the group, perhaps by consulting the teachers on the eligibility of the composition.

Observations: As with prior techniques, a guide was developed based on our goals listed in Section III-A. The level of interaction between the researcher and the participant was relatively minimal and passive, with minor guidance offered to ensure that the participant was able to proceed between the scenarios. We believe that this helped alleviate the reoccurring issue of shyness in participants and bypassed the need for any elaboration on their behalf.

While it would have been preferable to record the observation sessions on video, we decided against it due to ethical reasons as noted in Section III-F. As such, the sessions were recorded using hand-written notes which proved to be somewhat difficult, as the researchers were not always able to maintain the same speed as the participants. A video recording might have led to more results as they could have been further studied in detail in unison with other researchers, but is not without its drawbacks, including ethical considerations.

Despite using hand-written notes, Observations resulted in the highest number of distinct requirements of all techniques tested and required a significantly smaller time investment as well.

It's interesting to note the significant difference in satisfaction between Observations and other techniques. Questionnaires were a completely passive technique, demanding only that the participant uses the legacy system and answers a short questionnaire. Observations had a slightly higher level of interaction between the researcher and participant (see Section III-F), yet did not require anything from the participant after using the legacy system. The limited level of interaction between the participants and researchers may have been beneficial.

It should be noted that the high level of participant satisfaction for Observations may have been influenced by the quality of the legacy simulators; if the participants were to use a low quality system or a system they found uninteresting, it might not have been nearly as enjoyable. In our case, the system was explicitly intended for entertainment.

B. Comparison of Techniques

In the following subsection, we analyze different factors that we believe influenced the results of the different techniques.

Motivation and Attention Span: We noticed that nearly all of the techniques compared were highly dependent on the participants' willingness to work together with the research team and their interest in the technique at hand. Since Observations are more passive, they were not affected by this factor which can be seen as a strength of this technique. While Focus Groups, Questionnaires and Interviews still produced usable results with uninterested participants, a storyboarding session with uninterested participants can result in data that is very hard to interpret and work with. This was the case in one of our sessions, as discussed earlier.[3].

The long sessions of Storyboarding may be one of the reasons the motivation and attention were varying throughout each session. This is to be expected due to the shorter attention span of children, and is why we kept the sessions relatively short compared to what is common for Storyboarding sessions [22]. However, they were still too long, and the sessions might have benefited from a few breaks. In the context of Interviews, taking breaks is supported by Prior, who recommends the interviewer to "pay attention to the social signals of children, such as appearing tired" [31] and suggesting a break if necessary.

[3]Storyboarding session 2, see Appendix B, Figure 16

Age: While conducting the sessions with younger children, we noticed that they sometimes were shyer than older participants. Furthermore, we noticed that they often seemed unwilling or unable to elaborate on their answers, which led to data that was harder to generate requirements from.

Passive vs Active: A major difference in our techniques was the either passive or active approach we took when working together with participants. Questionnaires were the only technique that was intended to be purely passive which as stated earlier did not quite work out. In our case, there was a lack of incentive which could easily have been solved with a small gift or something similar. However, a passive technique also does not allow asking follow-up questions or clarifications. Note that as stated earlier, our Observations were not conducted in a fully passive manner, and therefore did not have this problem. We argue that entirely passive techniques should not be exclusively relied on unless there are strong reasons to do so, such as access to a high number of motivated participants.

Stating that, our overall approach consisted of mostly active techniques, in which the process relied heavily on constant interactions between researchers and participants. These techniques, i.e. Focus Groups, Interviews and Storyboarding, suffered when the participants were unwilling or unable to engage with the researchers and other participants. Observations did not require the participants to explain their actions or to further elaborate their views, but permitted them to do so in the cases where they wanted to explain their experience. We see the benefit of this when the results of our observation sessions are compared to the results of other techniques.

Confirmation bias: The type and usefulness of the requirements elicited depends heavily on the instruments and the expectations of the researchers, as discussed further in section V-D.

We aimed for consistency when creating the instruments and focused on the same areas of functionality. Nevertheless, in retrospect we can easily see that small differences such as having a particular scenario (e.g. how to sit at the proper height) in the Storyboarding instruments can certainly bring up more solutions to that problem than in other techniques where the corresponding question was more abstractly formulated.

This is a problem when conducting research, but it does not necessarily have to be a significant problem for product design, as long as one is aware of this. This depends to some extent on whether the elicitation effort is conducted early or late in the process. If the aim is to conduct the requirements elicitation early with the fewest possible assumptions, special care has to be taken to minimize the amount and extent of leading questions. If the elicitation is done later in the process, possible expectations on the system are not such a big problem, and the amount of effort put into minimizing this bias can be chosen as desired.

Fixed alternative questions: Some of our yes/no questions were not very usable. For example, we asked ”Did you land? How did it go?”, and had both Yes/No alternatives and space to elaborate. When interpreting the data, we realized that the fixed alternative answers to such a question does not say very much in themselves - if the user did not land, we could not know if they even tried or wanted to, and therefore could draw no conclusions about whether they found this challenging. The conclusion is that the fixed alternative questions either should aim to reveal something more concrete, or be grouped in such a way that the interesting information can be deducted from reviewing the answers from two or more questions.

Instruments: In order to validate and improve the instruments, gathering expert opinions beforehand is of great help. We reviewed our instruments with scientific or industry experts that had prior experience in conducting a certain technique and could point out possible weaknesses. This feedback was essential, especially in cases where a pilot could not be conducted. Surprisingly, we noticed that the expert feedback was more helpful than the data collected through the pilots.

The Composition of Groups: Group-based techniques should be conducted with participants that are comfortable working within a group setting. As discussed earlier, we encountered a group were the children were less comfortable interacting with each other.[4] We argue that this can happen in any group activity. Therefore, special care should be taken while composing these groups.

C. Guidelines

In this section we offer a few guidelines based on our experience and findings during this thesis work.

The factors that affect the decision of which technique to use include:

- Access to a similar legacy system or prototype.
- Access to children who are familiar with each other.
- The need for a wide range of requirements types.
- The need for especially imaginative requirements.

Based on these factors, we recommend the following guidelines:

- Given that a prototype or legacy system is in place, Observations may prove to be both an effective and efficient solution. This may be dependant on the quality and type of the prototype or legacy system at hand.
- Focus Groups and Interviews also performed very well. Focus Groups are ideally conducted with a group of children that are familiar with each other, but in our case had the strength of resulting in the highest amount of different types of requirements.
- Storyboarding presents itself as a kind of wild card. The benefits in conducting it in the manner described in this paper includes that it does not require a legacy system or prototype, and that it can elicit some very imaginative requirements. The strength of this technique seems to lie in the ability to elicit game-related requirements. The long sessions require a lot of effort from the participants, but they seem to enjoy participating.
- Questionnaires is a technique that relies heavily on the number of participants. In our case, Questionnaires

[4]Focus Groups, session 1, see Appendix IV, Figure 17.

performed the worst in terms of efficiency, which as discussed previously would improve with a larger amount of respondents. However, it also had the lowest usefulness rating, casting doubt on its eligibility for use with children.

Tips for Requirements Elicitation with Children

- The way questions are asked, as well as what is being sought after while discovering requirements, may affect findings.
- Remember to create and maintain a non-authoritative atmosphere when working with children. Child-friendly introductions can help to start a positive session.
- On the same note, start the sessions with simple, light questions, e.g. about their age or if they liked the prototype.
- For all group based techniques, it's useful when the children are familiar with each other.
- Observations: Although they are often done in an entirely passive way, we had good results with our semi-passive approach where some interaction and dialogue was made possible.
- Focus Groups and Interviews: Semi-structured sessions are recommended, due to their flexibility and possibility to ask follow-up questions. Remember that not all children will be comfortable with elaborating on their answers.
- Storyboarding: These sessions are relatively long and require the participant to focus on the scenario at hand and are sensitive to interruptions from within the group or outside entities. These issues can often be remedied by having breaks or other activities that may help the participants focus.
- Questionnaires: If including fixed alternative questions, make sure you have an idea on how to interpret the answers. Keep in mind that you will not be able to ask for clarifications afterwards.

D. Internal Validity Threats

Language Barrier: The elicitation sessions were mostly conducted in the Swedish language. Only one session was held in German.[5] Two of the three researchers are not native Swedish speakers, which may have had an impact on the flow of the discussion.

Nevertheless, these two researchers have sufficient Swedish skills and felt comfortable in conducting the sessions without the native Swedish researcher being present, in the rare cases where this was necessary due to logistical reasons.

Translations: As discussed earlier, the majority of techniques were conducted in Swedish. However, instruments were initially designed in English in order to synchronize with the researcher and industry expert who reviewed the work. These artifacts were then translated to Swedish and German.

Regardless of the language used during each session, all discovered requirements were formulated in English. There is a risk that subtle nuances in how the children voiced their opinions were lost in translation. Therefore, special care was taken when formulating the requirements.

Inexperience: The researchers did not have prior experience with any of the techniques. This may have had an impact on the time required to create the instruments as well as the quality of the execution of the elicitation sessions. To mitigate the impact of this, all instruments were reviewed by experts, and pilots were conducted where applicable.[6]

Discovery Process: As discussed in Section III-G, discovery of requirements from the artifacts produced during each session was conducted individually in a randomized order for each researcher to minimize the risk of a common learning bias.

The process of first discovering requirements individually and then merging them into a common list also minimized the risk of accidentally omitting requirements.

In order to verify that the requirements were well-formed and valid, they were reviewed by a requirements engineering expert.

Categorization into functional and non-functional requirements: In order to ensure accuracy, our categorization into functional and non-functional requirements was reviewed by a requirements engineering expert.

Learning Bias: Throughout this study, different types of learning bias were considered threats to validity.

While developing the material and instruments for each technique, we as a research team were able to reuse the parts of the material from prior techniques that were applicable for future ones (e.g. instruments created for Interviews were highly reusable for Focus Groups as well).

We anticipated another possible learning bias affecting the discovery of the requirements themselves: while doing this sort of work, a certain learning/training effect is to be expected. To counteract this possible learning bias, each researcher started the requirements discovery process with a different technique, and continued with a different order than the others, as described in Section III-G.

Confirmation bias: Regardless of the quality of the instruments, there is no way to avoid that the answers will depend heavily on how the questions are asked, and when discovering requirements from the session material there is a high risk to find what you are looking for, consciously or subconsciously. This is a form of confirmation bias that is hard to avoid, unless the researcher has no expectations on what the requirements elicitation effort may bear.

[5] Storyboarding session 1, see Appendix B, Figure 15.

[6] See discussions in their respective subsections in III.

This is virtually impossible to avoid, but something that needs to be discussed. In Section V-B, these effects are discussed in relation to the results.

Researchers Involved: Not all of the elicitation sessions were conducted by the same individual researchers. The number of researchers also varied between sessions in Storyboarding and Interviews.

We mitigated the effects of this threat by including thorough briefings among the researchers prior to conducting each technique, as well as keeping well-documented instruments.

Pilot Sessions: We aimed to conduct pilot sessions for all techniques, but only did this extensively for Questionnaires and Interviews due to the reasons listed below. This may have impacted our results in such a way that the instruments were better developed in those cases where a pilot was conducted.

A pilot was not conducted for Focus Groups due to the similarities with Interviews in addition to the fact that we once tried conducting an interview with two participants and verified that our interview questions worked well in this case as well. Therefore, we assume that no major changes would have been necessary if we had conducted a pilot session.

Regarding Observations, no pilot was conducted due to time constraints. However, after conducting the sessions, we did not feel that any changes to the observation guide was necessary, so a pilot would most likely not have affected the way we conducted these sessions.

No pilot was conducted for Storyboarding due to our inability to gather participants for a pilot group, as this technique requires the greatest amount of participant time for each session. A pilot might have revealed something that could be improved on, e.g. that the questions/scenarios could be wider or more numerous.

To summarize, Storyboarding is the technique most likely to be affected by the lack of a pilot session. We recognize this threat and acknowledge that this may have affected the results.

Participant Satisfaction: As stated in Section III-H, we measured participant satisfaction based on our subjective opinions. We felt that participants were likely to give inaccurate answers when asked about their participation in a particular session, in order to avoid offering disappointment.

Using our own impressions counters this problem, but introduces another one: subjectivity. This has been kept in mind when drawing conclusions from this data.

E. External Validity Threats

Difference in Age Range: Significant difficulties were faced when finding eligible participants for our research efforts, often due to scheduling constraints on their behalf. We elected to contact local schools in order to gather participants for the group-based techniques.

Accommodating to the children's and their school's busy schedule was difficult. As mentioned by McKnight and Read [32], this is a common issue faced when conducting studies with children, which in our case limited both our time with the participants, as well as our ability to get an even age distribution for some techniques. We decided to allow exceptions of +/- 1 year from the originally decided range of 9-12 in order to gather the data required.

Difference in Samples: Our samples can be placed into the following categories:

- *The school class (judgment sampling)*, in which the children were there as a mandatory part of their school day, and where the interest level and domain knowledge of the children can be expected to be around average.
- *Museum visitors (simple random sampling)*, in which the children were at the location voluntarily as a part of their daily activities. As such they may have a higher than average interest and knowledge in the domain at hand.
- *Off-location participants (snowball sampling)*, in which the children were participating voluntarily in their spare time, and where the interest level and domain knowledge of the children can be expected to be around average.

Ideally, we would have a consistent sample. As previously discussed, this was not possible, in part due to the nature of the techniques applied. This may have skewed the data, but our impression is that the museum visitors with a higher domain knowledge sometimes gave more concrete answers such as "I want G-force effects", but not necessarily more numerous or more useful requirements.

Difference in location: All techniques, aside from Storyboarding, were conducted at the museum. Storyboarding was conducted off-location in Sweden and Germany.

This may have affected the results, but since the number of participants in our study are so low, the cultural differences are likely to be smaller than the individual differences in background and personality.

Domain: All techniques, aside from Storyboarding, were conducted using a specific legacy system. The properties of this system might have influenced our findings in such a manner that is difficult to reproduce without it. However, these techniques were dependant on a legacy system or prototype being available and these results would always be influenced by the properties of that system.

In our case, our system is an entertainment system, which may for example affect how the participants enjoyed using it. As discussed previously, a more mundane system could possibly have given other results regarding the participant satisfaction and overall motivation to participate in the research.

VI. Conclusions

In this case study, we compared five different requirements elicitation techniques in regard to their efficiency and effectiveness when used with children. The majority of these techniques performed well, while one technique (Questionnaires) showed flaws in regard to the compatibility with children as participants. Recommendations on which technique(s) to use under which circumstances have been discussed.

We believe that our guidelines can help the industry in creating more child-friendly applications, and that providing some data regarding efficiency and effectiveness of elicitation techniques used with children can be helpful for the research

community, since to our knowledge no such comparison has been made.

The requirements elicited have been used while designing the new simulator at Aeroseum. Examples of requirements that will be included in the project: an electrically adjustable seat, a moving map clearly showing where airports are located, a three-monitor setup providing a wide field of view, and more.

Due to the limitations of this case study, further research should be conducted to confirm or refute our results, particularly with more participants in different settings. An in depth exploration of efficiency could also prove to be interesting, for instance comparing the effort required for different parts of the elicitation process such as instrument creation and requirements discovery.

ACKNOWLEDGMENT

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APPENDIX A
INSTRUMENTS

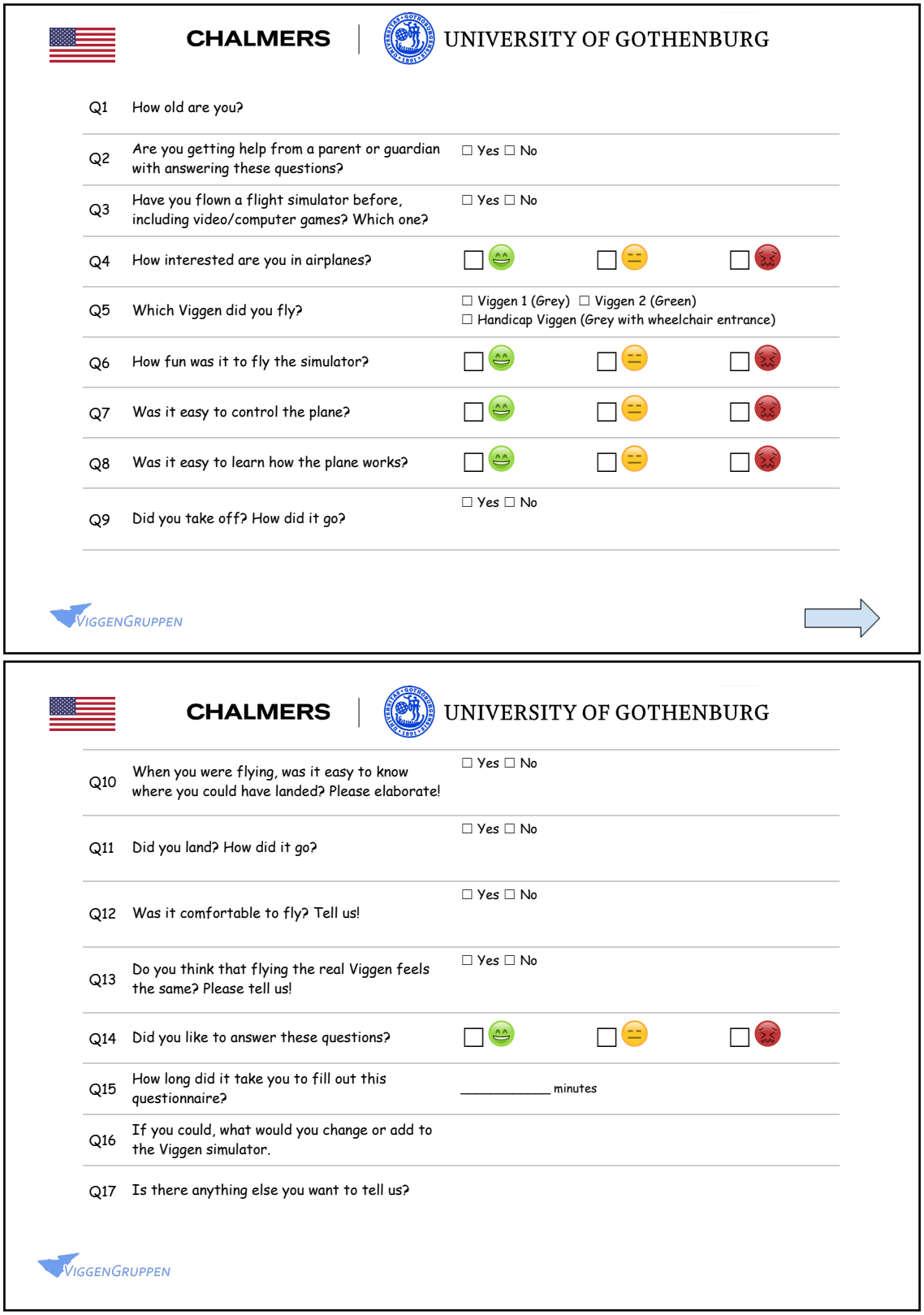

Fig. 9. Questionnaire

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Before the interview

- "We are building a new simulator and would like to know what you think about the old ones". Ask if they would like to participate in an interview that would help us a lot, it takes at most 15 minutes. Ask parents if it is okay that the children get a small thank you gift in form of candy.
- Everything is handled anonymously!

During the interview

1) Present ourselves.
   a) We are three persons from Gothenburg University currently writing our Bachelor thesis
   b) We are researching on how to take children's opinions into account when developing/"building" systems (such as a simulator)
2) Clarify that we're interested in what they think, there's no right or wrong answer. It's ok to be honest, so if you don't like something, it's ok to say that.

Interview questions

REMINDER: START TIMER

Q1. How old are you?
Q2. How interested are you in airplanes?
Q3. Have you flown a flight simulator before, including video/computer games? Which one?
Q4. Which simulator did you use?
Q5. How fun was it to fly the simulator?
Q6. Was it easy to learn how the plane works?
Q7. Was it easy to control the plane?
Q8. Did you take off? How did it go?
Q9. When you were flying, was it easy to know where you could have landed?
Q10. Did you land? How did it go?
Q11. What else did you try to do?

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Q12.1. What was fun?
Q12.2. What was not so much fun?
Q13.1. What was easy?
Q13.2. What was not so easy?
Q14. Was it comfortable to fly?
Q15. Do you think that flying the real Viggen feels the same?
Q16. If you could, what would you change or add to the Viggen simulator?

REMINDER: STOP TIMER

Checklist

C1. How involved is the parent during the interview? (Scale 1-5)
C2. How long did the interview take?
C3. Did the kid seem to enjoy it?
C4. Did the parent seem to think the kid enjoyed it? (Ask the parent)

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Fig. 10. Interview guide

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Materials Necessary

- (Color) Pens
- A4 papers for sketching initial thoughts
- A3 or A2 papers for the final storyboards

Introduction ~5 minutes

- Explain what we are doing
  - We are from Gothenburg University
  - Studying Software Engineering
  - Conducting research in regard to children's requirements/interests when developing new systems
- Explain what this session is about
  - We want to test how storyboarding can be used to get those requirements from children
  - Storyboarding is originally used by filmmakers to lay out a storyline
- Explain how the session is conducted
  - We will present the different scenarios you are supposed to work on
  - Each scenario should not exceed 15 minutes - we aim to be done after one hour
  - For each of those scenarios, you are supposed to work in your whole group to come up with a final storyboard
  - This is a creative process - that means everybody is always right and no one is wrong
  - Initially, gather loose ideas and then draw the storyboard from those ideas
  - Each storyboard should be between 3 to 5 panels long
  - You can draw people as well! Yourselves, your friends, your parents or teachers! It's ok if they're stick figures!
  - If you want to tell us something about what you drew, just write it below! We can help you with that, too!

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Scenario 1 (Goal 3)

"You're sitting in the plane now! But everything is so strange and so many buttons! You need someone - or something - to help you fly this thing! How do you think you'll get that help?"

Scenario 2 (Goal 5)

"The plane is made for grownups, how do you think you will even fit inside it and see everything?"

Scenario 3 (Goal 4 and Goal 6)

"The best part about flying is being in the air. Which you aren't. Let's get this plane off the ground! How do you think it would be best to do that?"

Scenario 4 (Goal 1 and Goal 2)

"Finally, you are in the air! What fun things do you want to do?"

Scenario 5 (Goal 4 and Goal 6)

"Uff, long flight. It's time to find a landing spot. How can you find it? How are you going to land?"

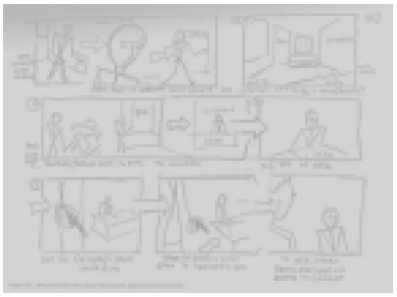

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Fig. 11. Storyboarding guide

This image is distorted due to copyright reasons.

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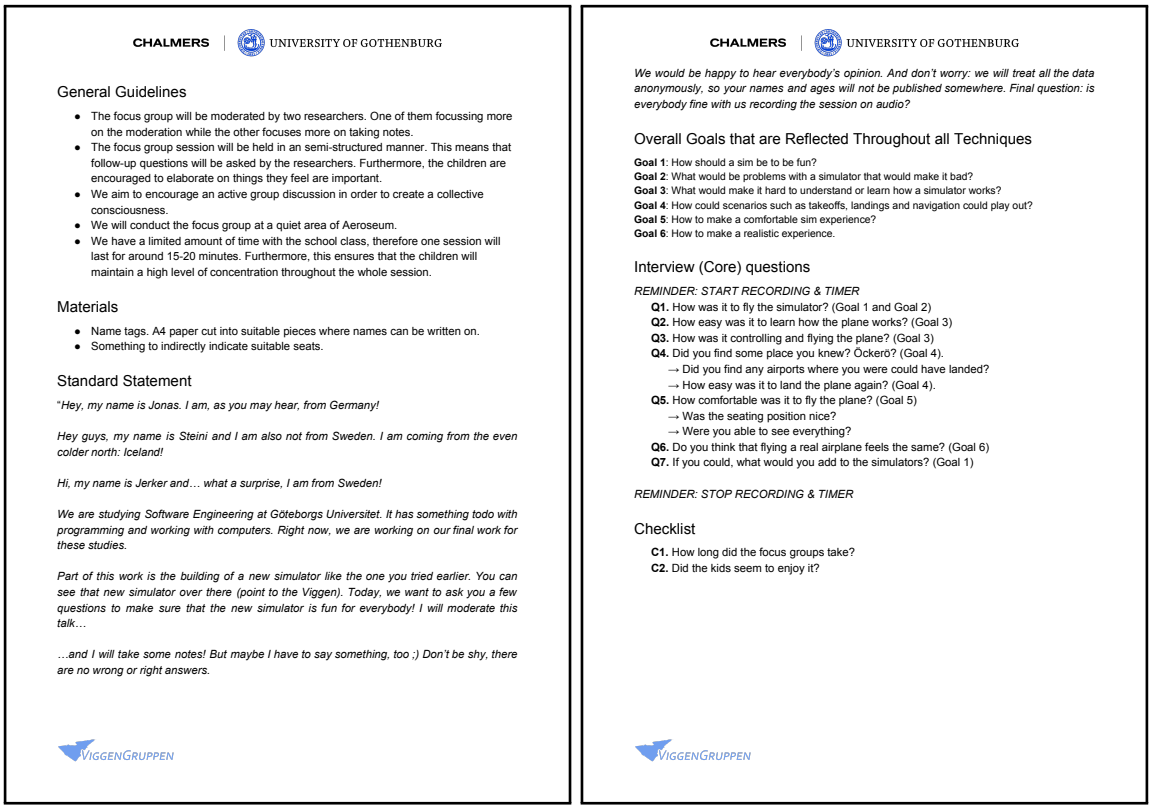
Fig. 12. Storyboarding guide cont.

Plane image by Peter Foster, PeterFoster@air2airpix.co.uk
Cockpit image by Erik Gustavsson, www.plasticwarfare.se



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General Guidelines

- The focus group will be moderated by two researchers. One of them focussing more on the moderation while the other focuses more on taking notes.
- The focus group session will be held in an semi-structured manner. This means that follow-up questions will be asked by the researchers. Furthermore, the children are encouraged to elaborate on things they feel are important.
- We aim to encourage an active group discussion in order to create a collective consciousness.
- We will conduct the focus group at a quiet area of Aeroseum.
- We have a limited amount of time with the school class, therefore one session will last for around 15-20 minutes. Furthermore, this ensures that the children will maintain a high level of concentration throughout the whole session.

Materials

- Name tags. A4 paper cut into suitable pieces where names can be written on.
- Something to indirectly indicate suitable seats.

Standard Statement

"*Hey, my name is Jonas. I am, as you may hear, from Germany!*

Hey guys, my name is Steini and I am also not from Sweden. I am coming from the even colder north: Iceland!

Hi, my name is Jerker and… what a surprise, I am from Sweden!

We are studying Software Engineering at Göteborgs Universitet. It has something todo with programming and working with computers. Right now, we are working on our final work for these studies.

Part of this work is the building of a new simulator like the one you tried earlier. You can see that new simulator over there (point to the Viggen). Today, we want to ask you a few questions to make sure that the new simulator is fun for everybody! I will moderate this talk…

…and I will take some notes! But maybe I have to say something, too ;) Don't be shy, there are no wrong or right answers.

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We would be happy to hear everybody's opinion. And don't worry: we will treat all the data anonymously, so your names and ages will not be published somewhere. Final question: is everybody fine with us recording the session on audio?

Overall Goals that are Reflected Throughout all Techniques

Goal 1: How should a sim be to be fun?
Goal 2: What would be problems with a simulator that would make it bad?
Goal 3: What would make it hard to understand or learn how a simulator works?
Goal 4: How could scenarios such as takeoffs, landings and navigation could play out?
Goal 5: How to make a comfortable sim experience?
Goal 6: How to make a realistic experience.

Interview (Core) questions

REMINDER: START RECORDING & TIMER

Q1. How was it to fly the simulator? (Goal 1 and Goal 2)
Q2. How easy was it to learn how the plane works? (Goal 3)
Q3. How was it controlling and flying the plane? (Goal 3)
Q4. Did you find some place you knew? Öckerö? (Goal 4).
→ Did you find any airports where you were could have landed?
→ How easy was it to land the plane again? (Goal 4).
Q5. How comfortable was it to fly the plane? (Goal 5)
→ Was the seating position nice?
→ Were you able to see everything?
Q6. Do you think that flying a real airplane feels the same? (Goal 6)
Q7. If you could, what would you add to the simulators? (Goal 1)

REMINDER: STOP RECORDING & TIMER

Checklist

C1. How long did the focus groups take?
C2. Did the kids seem to enjoy it?

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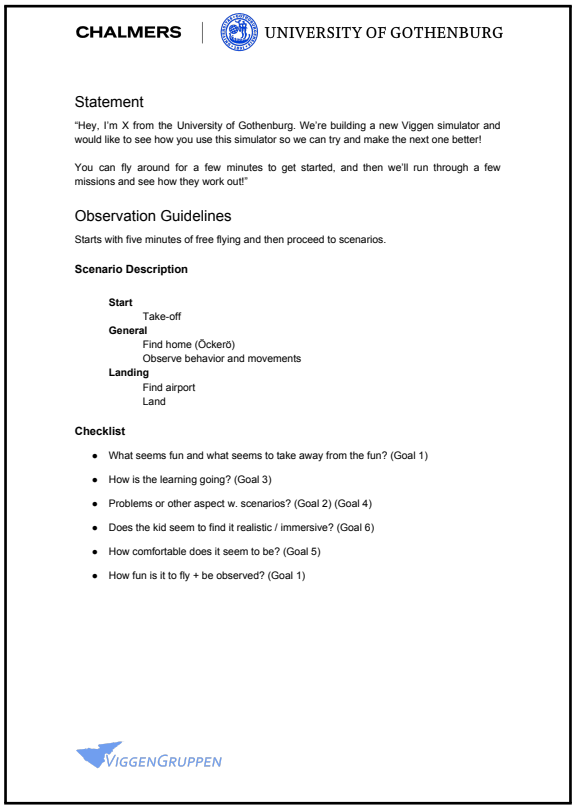
Fig. 13. Focus Groups guide



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Statement

"Hey, I'm X from the University of Gothenburg. We're building a new Viggen simulator and would like to see how you use this simulator so we can try and make the next one better!

You can fly around for a few minutes to get started, and then we'll run through a few missions and see how they work out!"

Observation Guidelines

Starts with five minutes of free flying and then proceed to scenarios.

Scenario Description

Start
Take-off
General
Find home (Öckerö)
Observe behavior and movements
Landing
Find airport
Land

Checklist

- What seems fun and what seems to take away from the fun? (Goal 1)
- How is the learning going? (Goal 3)
- Problems or other aspect w. scenarios? (Goal 2) (Goal 4)
- Does the kid seem to find it realistic / immersive? (Goal 6)
- How comfortable does it seem to be? (Goal 5)
- How fun is it to fly + be observed? (Goal 1)

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Fig. 14. Observations guide

APPENDIX B
RESULTS

TABLE XVII
QUESTIONNAIRES, QUALITATIVE DATA

#	Q3: Have you flown a flight simulator before, including video/computer games?
5	Yes: on computer, mobile and here (meaning other legacy simulators)
7	Yes: computers and the Bulldog (a legacy simulator)
#	Q9: Did you take off? How did it go?
1	Yes: It went well.
2	Yes: It went well the third time.
4	Yes: It went well.
5	Yes: It went quickly and easy.
7	Yes: It went well except for that the airplane did not start on the runway.
8	Yes: Fine.
9	Yes: Good, I guess.
10	Yes: Great.
#	Q10: When you were flying, was it easy to know where you could have landed? Please tell us!
1	Yes: I landed when I wanted.
2	Yes: I landed in the water.
4	No: I did not see where I could land.
7	No: It wasn't very clear.
#	Q11: Did you land? How did it go?
1	No: I crashed, that went well.
2	Yes: It went well.
4	No: I did not land.
5	Yes: I landed but was not able to take off again.
10	Yes: It was difficult.
#	Q12: Was it comfortable to fly? Tell us!
1	Yes: The chair was comfortable. It was lovely to fly!
2	Yes: It was fun.
3	Yes: It comfortable.
4	Yes: Nice controls.
5	Yes: It wasn't straight off uncomfortable but not the best in the world either.
7	Yes: Because it was like sitting in a real airplane (note: unclear whether this sentence was an answer to question 12 or 13).
#	Q13: Do you think that flying the real Viggen feels the same? Please tell us!
1	No: A bit harder.
2	No: A bit harder.
4	Maybe.
5	No: There would be G forces and rotation.
7	Because it was like sitting in a real airplane (note: unclear whether this sentence was an answer to question 12 or 13).
10	Hard to tell have not flown real.
#	Q16: If you could, what would you change or add to the Viggen simulator?
5	Indicators for runways and weapons.
10	Shoot.
13	*Unreadable, perhaps "heavy throttle"*.
#	Q17: Is there anything else you want to tell us?
7	All controls did not always work.

TABLE XVIII
QUESTIONNAIRES, FIXED ALTERNATIVE DATA

Participant #	1	2	3	4	5	6	7	8	9	10	11	12	13
Q1: How old are you?	12	12	12	12	13	10	12	10	10	13	10	12	9
Q2: Are you getting help from a parent or a guardian while answering these questions?	No	No	No	No	No	No	No	Yes	No	No	No	No	Yes
Q3: Have you flown a flight simulator before, including video/computer games?	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes
Q4: How interested are you in airplanes?	Neutral	Neutral	Good	Neutral	Good	Good	Good	Good	Neutral	Good	Good	Neutral	Good
Q5: Which Viggen did you fly?	1	2	2	1	2	-	1	1	1	2	2	1	2
Q6: How fun was it to fly the simulator?	Good	Good	Good	Good	Good	-	Good	Good	Neutral	Good	Good	Good	Good
Q7: Was it easy to control the plane?	Good	Good	Neutral	Good	Good	Neutral	Good	Neutral	Good	Good	Neutral	Neutral	Bad
Q8: Was it easy to learn how the plane works?	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Neutral	Good
Q9: Did you take off? How did it go?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q10: When you were flying, was it easy to know where you could have landed? Please elaborate!	Yes	Yes	No	No	Yes	No	No	-	-	Yes	-	No	Yes
Q11: Did you land? How did it go?	No	Yes	No	No	Yes	No	No	-	-	Yes	-	No	No
Q12: Was it comfortable to fly? Tell us!	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	Yes	-	Yes	Yes
Q13: Do you think that flying the real Viggen feels the same? Please tell us!	No	No	No	-	No	Yes	-	-	-	Yes+No	-	No	No
Q14: Did you like to answer these questions?	Good	Good	Good	Neutral	Good	Good	Good	-	-	Good	-	Good	Good
Q15: How long did it take you to fill out this questionnaire? (Minutes)	5	4	3	7	2	3	2	-	-	2	-	2	2

TABLE XIX
INTERVIEW NOTES

Interview #2	
How old are you?	8, soon to be 9
Are you interested in airplanes?	Very much!
Have you flown a simulator before, perhaps as a video game? Which one?	Yes, on the TV.
Which plane did you fly?	Piper, Bulldog & HK Viggen
Was it fun to fly the airplane?	Quite fun, like all the other planes
Was it easy to learn how everything worked?	Quite easy
Was it easy to steer the plane?	Quite easy. Hard to keep on track. Easy to steer
Did you manage to take off? How did it go?	Yes, without issues
When you were flying, was it simple to know where you could land? Please elaborate.	No, it was hard. Did find an airport however.
Did you land? How did it go?	No, it was hard. The plane bounced.
What more did you try to do?	Loops. That went well.
What was fun?	Piper was the most fun. Easy and quick to fly.
Was wasn't so much fun?	No.
What was simple to do?	Don't know.
What wasn't so simple to do?	Don't know.
Was it comfortable to fly?	Yes, the HKP Viggen was okay.
Do you believe that the simulator feels like a real airplane? Please elaborate.	No. It didn't shake. Wants it to feel more like a realistic plane.
Would you like to change or add something to the simulators if you could?	It didn't shake. I want the plane to shake!
Is there anything else you would like to tell us?	No!
Interview #3	
How old are you?	8
Are you interested in airplanes?	Yes.
Have you flown a simulator before, perhaps as a video game? Which one?	Yes, in a simulator and in a real one in my father's job (he's a pilot)!
Which plane did you fly?	—
Was it fun to fly the airplane?	Yes!
Was it easy to learn how everything worked?	Yes!
Was it easy to steer the plane?	Yes, good! A little bit hard here and there.
Did you manage to take off? How did it go?	Yes.
When you were flying, was it simple to know where you could land? Please elaborate.	Yes.
Did you land? How did it go?	No, hard to steer.
What more did you try to do?	I did loops.
What was fun?	Just flying
Was wasn't so much fun?	Nothing.
What was simple to do?	Taking off.
What wasn't so simple to do?	No.
Was it comfortable to fly?	Yes!
Do you believe that the simulator feels like a real airplane? Please elaborate.	It's hard to tell!
Would you like to change or add something to the simulators if you could?	No.
Is there anything else you would like to tell us?	No.
Interview #5	
How old are you?	11
Are you interested in airplanes?	A little.
Have you flown a simulator before, perhaps as a video game? Which one?	I played a bit on the iPad.
Which plane did you fly?	The Piper.
Was it fun to fly the airplane?	It was!
Was it easy to learn how everything worked?	Yes!
Was it easy to steer the plane?	Not easy. Flew into circles quite a lot despite not intending to.
Did you manage to take off? How did it go?	Yes, it was easy!
When you were flying, was it simple to know where you could land? Please elaborate.	Never saw a landing spot.
Did you land? How did it go?	Tried to, but it didn't go well.
What more did you try to do?	Loops! Didn't go well either.
What was fun?	Pulling the stick!
Was wasn't so much fun?	The terrain was green and uninteresting
What was simple to do?	Taking off.
What wasn't so simple to do?	Steering.
Was it comfortable to fly?	Yes!
Do you believe that the simulator feels like a real airplane? Please elaborate.	Never flown a real plane, but imagines it could be somewhat similar!
Would you like to change or add something to the simulators if you could?	Increased scenery details. Have houses and such!
Is there anything else you would like to tell us?	No!

TABLE XX
INTERVIEW NOTES, CONTINUED

Interview #6	
How old are you?	11,5
Are you interested in airplanes?	No, not so much.
Have you flown a simulator before, perhaps as a video game? Which one?	I've flown before (in a computer game)
Which plane did you fly?	Piper
Was it fun to fly the airplane?	It was fun!
Was it easy to learn how everything worked?	Yes - it was very easy.
Was it easy to steer the plane?	Quite easy, but hard to see where you could fly to!
Did you manage to take off? How did it go?	It was easy and went well.
When you were flying, was it simple to know where you could land? Please elaborate.	It was a bit hard when you tried to find an landing spot
Did you land? How did it go?	Yes - but I crashed.
What more did you try to do?	Loops, but that didn't go well.
What was fun?	It felt real!
Was wasn't so much fun?	Trying to find a place to land was not so fun.
What was simple to do?	Easy to steer
What wasn't so simple to do?	Landing.
Was it comfortable to fly?	Very comfortable!
Do you believe that the simulator feels like a real airplane? Please elaborate.	Quite similar.
Would you like to change or add something to the simulators if you could?	Scenery, I want to see more houses
Is there anything else you would like to tell us?	-
Interview #7	
How old are you?	9
Are you interested in airplanes?	It depends.
Have you flown a simulator before, perhaps as a video game? Which one?	This was the first time
Which plane did you fly?	Piper
Was it fun to fly the airplane?	Neither good or bad.
Was it easy to learn how everything worked?	I just used three things
Was it easy to steer the plane?	It was easy to move forward but it didn't go very fast
Did you manage to take off? How did it go?	Yes! It was easy!
When you were flying, was it simple to know where you could land? Please elaborate.	No. Hard to tell airport apart from the land side.
Did you land? How did it go?	I didn't try to land
What more did you try to do?	Just fly!
What was fun?	I don't know
Was wasn't so much fun?	Flying was slow
What was simple to do?	Flying was easy
What wasn't so simple to do?	Loops, I crashed when trying.
Was it comfortable to fly?	Yes!
Do you believe that the simulator feels like a real airplane? Please elaborate.	I don't know. Maybe!
Would you like to change or add something to the simulators if you could?	I'm not sure, but maybe some help to find the airport
Is there anything else you would like to tell us?	-
Interview #8	
How old are you?	13
Are you interested in airplanes?	Not all that much, but I like planes.
Have you flown a simulator before, perhaps as a video game? Which one?	Yes, I flew a simulator in Stockholm and then at home.
Which plane did you fly?	Piper
Was it fun to fly the airplane?	Yes!
Was it easy to learn how everything worked?	Yes, it was.
Was it easy to steer the plane?	It went well!
Did you manage to take off? How did it go?	Yes, it went well.
When you were flying, was it simple to know where you could land? Please elaborate.	It was hard to see anything because of the resolution
Did you land? How did it go?	I've landed in simulators before, but not in this one.
What more did you try to do?	Tried flying under the Älvsborgsbron. I crashed.
What was fun?	The feeling of flying! Trying to fly. See how everything in the plane works.
Was wasn't so much fun?	It wasn't very realistic
What was simple to do?	Steering.
What wasn't so simple to do?	Finding a place to land.
Was it comfortable to fly?	Yes
Do you believe that the simulator feels like a real airplane? Please elaborate.	It was hard to use the screen, and it didn't feel realistic
Would you like to change or add something to the simulators if you could?	The scenery and houses need to be more detailed.
Is there anything else you would like to tell us?	No

TABLE XXI
INTERVIEW NOTES, CONTINUED

Interview #9	
How old are you?	13
Are you interested in airplanes?	Not so much, but they're cool though.
Have you flown a simulator before, perhaps as a video game? Which one?	First time.
Which plane did you fly?	Piper
Was it fun to fly the airplane?	Yes
Was it easy to learn how everything worked?	Yes, it was
Was it easy to steer the plane?	It went well.
Did you manage to take off? How did it go?	Yes, it went well and wasn't so hard.
When you were flying, was it simple to know where you could land? Please elaborate.	A little bit. Not so easy, but still easy.
Did you land? How did it go?	No. I tried though!
What more did you try to do?	I tried flying under the bridge. I crashed.
What was fun?	It was easy to steer and fly. I could go everywhere and see a lot.
Was wasn't so much fun?	It didn't look very realistic.
What was simple to do?	Steering.
What wasn't so simple to do?	Finding a runway.
Was it comfortable to fly?	Yes
Do you believe that the simulator feels like a real airplane? Please elaborate.	No, not at all. You feel safe and nothing happens to you if you crash.
Would you like to change or add something to the simulators if you could?	Would be nice to have a better view out the windows and increase the graphic levels.
Is there anything else you would like to tell us?	No!
Interview #10	
How old are you?	12
Are you interested in airplanes?	Not so super much, but they're cool!
Have you flown a simulator before, perhaps as a video game? Which one?	This is the first time.
Which plane did you fly?	Viggen 1
Was it fun to fly the airplane?	Yes!
Was it easy to learn how everything worked?	It was hard at first, but because easier later. It's hard to keep the plane straight on the runway when taking off.
Was it easy to steer the plane?	It was very, very sensitive!
Did you manage to take off? How did it go?	I took off 4 to 5 times and it went well. I had issues with the rudder first, but it went well later.
When you were flying, was it simple to know where you could land? Please elaborate.	I didn't even realize I was flying over Gothenburg!
Did you land? How did it go?	I landed in a field.
What more did you try to do?	Loops, going up and down quickly and making turns.
What was fun?	Loops and high speed turns!
Was wasn't so much fun?	Flying straight.
What was simple to do?	Flying straight.
What wasn't so simple to do?	Taking off initially. The plane was also shaky when I tried landing on the field.
Was it comfortable to fly?	The chair was good!
Do you believe that the simulator feels like a real airplane? Please elaborate.	I think it's similar. Turning while on the side seemed realistic!
Would you like to change or add something to the simulators if you could?	Maps and something to help navigate!
Is there anything else you would like to tell us?	No, but it was fun to fly!
Interview #11	
How old are you?	12
Are you interested in airplanes?	Not so much.
Have you flown a simulator before, perhaps as a video game? Which one?	It's the first time.
Which plane did you fly?	Piper
Was it fun to fly the airplane?	It was fun.
Was it easy to learn how everything worked?	It was easy, but quite hard to land.
Was it easy to steer the plane?	I thought so.
Did you manage to take off? How did it go?	Yes, it went well.
When you were flying, was it simple to know where you could land? Please elaborate.	No.
Did you land? How did it go?	No. I crashed.
What more did you try to do?	I tried to loop.
What was fun?	Taking off.
Was wasn't so much fun?	I didn't know where I could land.
What was simple to do?	Taking off and steering.
What wasn't so simple to do?	Just landing and positioning for landing
Was it comfortable to fly?	Everything was comfortable.
Do you believe that the simulator feels like a real airplane? Please elaborate.	No, because, I don't know really.
Would you like to change or add something to the simulators if you could?	No!
Is there anything else you would like to tell us?	It was fun!

TABLE XXII
INTERVIEW NOTES, CONTINUED

Interview #12	
How old are you?	12
Are you interested in airplanes?	Not that interested
Have you flown a simulator before, perhaps as a video game? Which one?	It's the first time.
Which plane did you fly?	Piper.
Was it fun to fly the airplane?	Yes! It felt realistic
Was it easy to learn how everything worked?	Yes, for the most part. It wasn't so easy to land though.
Was it easy to steer the plane?	Yes
Did you manage to take off? How did it go?	Yes, it went well!
When you were flying, was it simple to know where you could land? Please elaborate.	No! I had no idea where I could find a place to land.
Did you land? How did it go?	I crashed on the side of the runway. Landed on a road too.
What more did you try to do?	I tried making loops. Side loops and vertical loops.
What was fun?	Taking off and just flying.
Was wasn't so much fun?	It wasn't fun not knowing where I could land, and I didn't know that I was flying over Gothenburg.
What was simple to do?	Taking off! Steering. Rolling!
What wasn't so simple to do?	Landing was hard!
Was it comfortable to fly?	Yes. No issues.
Do you believe that the simulator feels like a real airplane? Please elaborate.	No. Everything is much more clearer when you're really flying.
Would you like to change or add something to the simulators if you could?	Add a map!
Is there anything else you would like to tell us?	-

TABLE XXIII
STORYBOARDING SESSION 1 METADATA AND NOTES

Time consumed	
Explanation and Introdcution	5 minutes
Scenario 1	11 minutes
Scenario 2	6 minutes
Scenario 3	16 minutes
Scenario 4	8 minutes
Scenario 5	9 minutes
Total length	55 minutes
General Notes	
3 girls, 12 years old, understood the topic very fast. Were excited to hear that they are supposed to draw a storyboard like they do in films. Had a lot of fun throughout the test. A lot of laughter. Lost a bit concentration in the very end, but great effort and job!	
Scenario Related Notes	
Scenario 1	Clever idea: ”I will call my dad - he is a pilot.” Me: ”There is no cell-phone perception.” ”Alright. Then there will be a guide helping us!”
Scenario 2	Instantly: ”Is this seat able to change the position?!”
Scenario 3	A bit more difficult. Did not understand from the beginning what this was all about. Had the feeling the scenario was boring for the girls due to it being a bit far fetched.
Scenario 4	Bigger fascination: ”Wow - we can describe whatever we want!”
Scenario 5	Was not problem for the girls!

TABLE XXIV
STORYBOARDING SESSION 2 METADATA AND NOTES

Time consumed	
Explanation and Introduction	12 minutes
Scenario 1	25 minutes
Scenario 2	10 minutes
Scenario 3	12 minutes
Scenario 4	8 minutes
Scenario 5	9 minutes
Total length	85 minutes
General Notes	
3 girls, two of them 11 years old, one 12 years old. A lot of laughter and fun while we showed the movie storyboards. They thought the characters were interesting and funny. Had some language difficulties as neither of us are Swedish speakers, but one of the participants helped with translation.	
Scenario Related Notes	
Scenario 1	Lots of discussions on how you would normally learn how to fly a plane and how it could be done in a less-serious scenario. They discussed the art-style as well. Disagreement on how they should receive instructions. Wanted both book for instructions and from a book. Used colors despite it not being needed, may have been an obstruction. Color pens seem to distract from “important” things.
Scenario 2	Extremely distracted. Forget the scenario purpose after a short time. Asked for the pizza they got promised for later.
Scenario 3	Started to draw fantasy Figure (e.g. a monster). We had the feeling that they stopped to take the research serious.
Scenario 4	Recurring theme: the girls asked for pizza.
Scenario 5	The girls wanted the session to be done pretty fast.

Fig. 15. Storyboarding session 1 results

Fig. 16. Storyboarding session 2 results

Q1. How was it to fly the simulator? (G 1 and G 2)

Moderator: How was it to fly the simulator?
Participant 1: It was fun!
Moderator: Which one did you fly?
Participant 1: The second one from the entrance (the Piper)
Moderator: How about the rest of you?
All participants agreed that the experience was entertaining.

Q2. How easy was it to learn how the plane works? (G 3)

All agree that it was.
Participant: It was easy.
Another participant: There weren't a lot of buttons.
Another participant: Yes, it was quite simple
Moderator: Did anybody have a hard time flying the plane?
Nobody said they had.

Q3. How was it controlling and flying the plane? (G 3)

Moderator: Was it hard to control the plane?
Participant: I flew the Viggen 2, it was a little bit hard sometimes. It was easier when flying straight.
Another Participant: I flew the Viggen 1 which was both easy and hard.
Moderator: Did anyone think it was too hard to steer their plane?
None of the participants thought it was exceedingly hard to steer their plane.

Q4. Did you find some place you knew? Öckerö? (G 4).

Moderator: Who here found an airport?
Two participants had found an airport.
Moderator: Was there anybody here who saw Öckerö?
Participant: I saw it!
Another participant: I tried to land there! (Piper pilot)
Moderator: How did the landings go in general?
Participant: Yes, I never managed to land.
Another participant: I landed once.
Moderator: Those who didn't find an airport and land, what was it that made it hard to find an airport?
Participant: Normal roads looked like they could've been airports and that was confusing.
Another participant: I thought it was simple to find an airport because the lights helped locate it. If you see them, you just go behind them and lower the speed…
Another participant 2: It was a bit hard to turn, I was in Viggen 2.

Q5. How comfortable was it to fly the plane? (G 5)

Moderator: Was it comfortable to fly? By that I mean the seats, the sitting position, seeing outside the windows and so forth.
There was agreement that the seats were comfortable.
Participant: There were scratches on the glass which made it a bit more difficult to see.

Q6. Do you think that flying a real airplane feels the same? (G 6)

Moderator: Do you think that it's similar to fly these simulators and real planes?
Participants: The simulators don't vibrate as real planes do.
Another participant: I think so as well.
Another participant 2: I thought it was kinda similar, but it should shake. It's a bit harder to fly a real plane.
Participant: When you land a normal airplane you can feel the vibrations and in the air you feel the turbulence.
Another participant 3: There are a lot more sounds as well.

Q7. If you could, what would you add to the simulators? (G 1)

Moderator: If you could, what would you add to the simulators?
Participant: Better graphics.
Another participant: Vibrations.
Another participant 2: Louder sounds.
Another participant 3: Perhaps we could have headphones for more noise?
Moderator: How about instructions? How would you like them? What would you do if there was no one there to instruct you?
Participants: You would have to look for the buttons, the start button and so forth.
Another participant: Just experiment.
Another participant 2: Perhaps labelled buttons and controls?

Fig. 17. First focus group transcription

Q1. How was it to fly the simulator? (G 1 and G 2)

Moderator: The first question is very difficult! How was it flying the simulators?

Participant: It was simple at first, taking off. But when it came to landing it was hard. It felt like I crashed when landing.

General agreement with this statement is heard from the participants.

Moderator: Yes, landing can be hard. What else did you notice when flying that wasn't fun?

Participant: It was hard to turn the plane on its side. It just did loops.

This participant flew the Handicap Viggen. A few nodded their heads in agreement, having been afflicted by this issue as well.

Q2. How easy was it to learn how the plane works? (G 3)

Moderator: Was is simple to learn how the simulator worked?

Participant: Yes!

Moderator: Did you get any help?

Participant: I got some help when starting out.

Participant was instructed by a simulator operator.

Moderator: This is something that we have to put a lot of work into. It's important that everybody knows how to use the simulator they're flying. How do you think it would be best to get help?

Participant 1: Perhaps using text-instructions?

Participant 2: Some labeling might help as well. It could say on the throttle that this is the throttle as an example.

Participant 3: You could also have an audio recording that could be played when someone new is flying, that you could listen to before you start flying.

Two other participants do not raise any further suggestions during this topic, but agree with the statements made by their peers.

Q3. How was it controlling and flying the plane? (G 3)

Moderator: How did handling the plane go?

Participant 2: It was easy using a wheel (*note: as opposed to a stick)*

Moderator: Ah, so you flew the Piper?

Participant 2: Yes.

Participant 4: I never intended to crash, but it happened when I wanted to land. But it was easy to steer once in the air.

The group is in unanimous agreement with participant 4's statement.

Q4. Did you find some place you knew? Öckerö? (G 4).

Moderator: Did any of you happen to find a place you were familiar with? Öckerö?

All participants, apart from one of them, answer this question negatively as they were initially not aware that the area they were flying over was the local Gothenburg area. One participant claims to have seen a local landmark in the very end.

Moderator: Were you able to find an airport to land on?

All participants were able to find an airport at some point. But this was difficult due to outdated graphics.

Moderator: What other issues did you have when finding the place you wanted to find, e.g. an airport, and why?

Participant: I didn't have a map!

Participant 5: I flew above an island, but it was hard to tell which one it was because the scenery (miljö) looks so old.

Participant 4: We were flying over the Gothenburg area?

Moderator: Yes. For those who tried landing, how was it?

All participants agree that it was hard.

Participant 3: I managed to touch down, but then I didn't know what to do.

Moderator: What was it that made it difficult?

Participant 3: Slowing down.

Participant 1: Staying on track and keeping the plane turning correctly. Finding the airport was hard as well.

Q5. How comfortable was it to fly the plane? (G 5)

Moderator: Was the simulator comfortable?

All participants agree that it was comfortable and their view was not obstructed.

Participant 5: I used a pillow to see out better.

Q6. Do you think that flying a real airplane feels the same? (G 6)

Moderator: Do you think that the simulators were similar to real airplanes?

All participants agree in unison that this was not the case.

Moderator: Could you tell us why?

Participant 1: The scenery (miljö) is much nicer.

Participant 5: And a real plane vibrates more

Participant 2: And you have to think more about the buttons and use more of them.

Participant 1: And you have to worry about crashing when flying a real plane. With the simulators we don't need to do this.

Q7. If you could, what would you add to the simulators? (G 1)

Moderator: If you could, what would you add to the simulators?

Participant 1: The ability to raise and lower the seat electrically

Participant 2: A few buttons that let you change your location, so you can see more.

Fig. 18. Second focus group transcription

TABLE XXV
OBSERVATION NOTES

Observation #1 (Viggen 1)	
What seems fun and what seems to take away from the fun?	Takes away: hard to find an airport, hard to control the plane.
How is the learning going?	Very hard to get started without guidance.
Problems or other aspects with scenarios?	Takeoff: possible after a lot of attempts but cannot stay (straight) on the runway. Find home: Not possible. Behaviour and movements: It was hard for her to control the plane.
Does the child seem to find it realistic / immersive?	Yes.
How comfortable does it seem to be?	Had a hard time to see everything.
How fun is it to fly and be observed?	No problem.
Other notes	
Observation #2 (Viggen 2)	
What seems fun and what seems to take away from the fun?	Takes away: has with trouble the controls, steers too much, overcorrects etc.
How is the learning going?	Good, clear improvement in flying after a while.
Problems or other aspects with scenarios?	Takeoff: OK. General: Flied in circles around Säve, seemed to keep track of where he was. Landing: approaches very close to the runway at a steep horizontal and vertical angle. Seems surprised when it doesn't work. Tried the same with landing on a road.
Does the child seem to find it realistic / immersive?	OK, seemed not too thrilled in that sense.
How comfortable does it seem to be?	OK except the limited view. It looked hard to climb out of the plane.
How fun is it to fly and be observed?	
Other notes	Trouble learning / remembering to release the parking brake. Constant stall warning. Gear always down.
Observation #3 (Viggen 2)	
What seems fun and what seems to take away from the fun?	Has a hard time with the controls, no prior knowledge or understanding. Straight from the beginning taxiing to the runway is hard.
How is the learning going?	Actually learned quickly.
Problems or other aspects with scenarios?	Takeoff: hard because the subject didn't realize the stick needs to be centered for the plane not to roll immediately after lifting off. Landing: OK approach distance, turned to sharply and failed.
Does the child seem to find it realistic / immersive?	Yes
How comfortable does it seem to be?	Good.
How fun is it to fly and be observed?	4/5.
Other notes	Flew basically straight ahead for the first five minutes.
Observation #4 (Viggen 1)	
What seems fun and what seems to take away from the fun?	Takes away: that the plane was difficult to fly.
How is the learning going?	Not good. The subject had a hard time flying the plane and complained that it was hard.
Problems or other aspects with scenarios?	Takeoff: subject said "oh, that doesn't work well". General: subject said "I cannot even steer properly".
Does the child seem to find it realistic / immersive?	Feels that it is realistic.
How comfortable does it seem to be?	Problematic.
How fun is it to fly and be observed?	No problem.
Other notes	The throttle stopped working.
Observation #5 (Viggen 2)	
What seems fun and what seems to take away from the fun?	
How is the learning going?	Learned fast how all controls work.
Problems or other aspects with scenarios?	Takeoff: No problem. General: Hard time to keep the plane stable. Find airport: kind of ok, land: Did not work out well, crash.
Does the child seem to find it realistic / immersive?	Yes, finds it realistic.
How comfortable does it seem to be?	Feels comfortable.
How fun is it to fly and be observed?	No problem.
Other notes	
Observation #6 (Viggen 1)	
What seems fun and what seems to take away from the fun?	Did not have so much fun. See other points.
How is the learning going?	Learned fast how to control the plane, just the brakes were a problem.
Problems or other aspects with scenarios?	Takeoff: problems with throttle + starting on a taxiway. Find home: not possible. Random flying. Just tries to fly.
Does the child seem to find it realistic / immersive?	Kind of, feeling.
How comfortable does it seem to be?	Hard time to see everything.
How fun is it to fly and be observed?	No problem.
Other notes	

TABLE XXVI
OBSERVATION NOTES, CONTINUED

Observation #7 (Viggen 1)	
What seems fun and what seems to take away from the fun?	The throttle is not working properly.
How is the learning going?	OK except learning how to use the parking brakes.
Problems or other aspects with scenarios?	Takeoff: fine, once he took off without releasing the brakes. I told him, he didn't seem to care. General: pointed the plane straight into the sky all the time, at least two minutes.
Does the child seem to find it realistic / immersive?	OK. Distracted by friends nearby.
How comfortable does it seem to be?	4/5.
How fun is it to fly and be observed?	4/5.
Other notes	
Observation #8 (Viggen 2)	
What seems fun and what seems to take away from the fun?	
How is the learning going?	Ok, better after a while but still too sharp turns. Needed help with pedals/brakes.
Problems or other aspects with scenarios?	General: steering sharply, high roll speed. Eventually gets used to it. Tries a loop, only manages half, then rolls back to level.
Does the child seem to find it realistic / immersive?	Yes.
How comfortable does it seem to be?	4/5.
How fun is it to fly and be observed?	4/5.
Other notes	
Observation #9 (Handicap Viggen)	
What seems fun and what seems to take away from the fun?	
How is the learning going?	Learning OK, flies straight and steadily.
Problems or other aspects with scenarios?	General: doesn't know where runway or self is.
Does the child seem to find it realistic / immersive?	Yes.
How comfortable does it seem to be?	Seems comfortable and like the view is good enough.
How fun is it to fly and be observed?	Not super thrilled.
Other notes	Brief observation notes, seemed to look good.
Observation #10 (Viggen 1)	
What seems fun and what seems to take away from the fun?	After taking off, does rolls, laughs and says to nearby friend that she's doing loops.
How is the learning going?	Learns everything quickly.
Problems or other aspects with scenarios?	Taking off: problematic because the throttle is not working properly. Taxiing is impossible, the only way to take off is to take off straight ahead since the throttle goes to max when it starts reacting. General: did rolls etc. Didn't get to other scenarios.
Does the child seem to find it realistic / immersive?	Yes.
How comfortable does it seem to be?	Very comfortable.
How fun is it to fly and be observed?	Very fun.
Other notes	Trouble with EBK zones on throttle.
Observation #11 (Viggen 2)	
What seems fun and what seems to take away from the fun?	Fun: the experience overall. Takes away: see below.
How is the learning going?	Learning how to keep the stick centered and how to use the pedals was challenging.
Problems or other aspects with scenarios?	Takeoff: needed 5-7 tries before getting the hang of it, see above. General: didn't get to scenarios, spent the rest of the time learning to fly in general.
Does the child seem to find it realistic / immersive?	Yes.
How comfortable does it seem to be?	Very comfortable.
How fun is it to fly and be observed?	Very fun. Excitedly screamed "I'm gonna die", afterwards "this was ** fun".
Other notes	Trouble with EBK zones on throttle.

TABLE XXVII
OBSERVATION NOTES, CONTINUED

Observation #12 (Handicap Viggen)	
What seems fun and what seems to take away from the fun?	
How is the learning going?	Harder to Figure out the buttons despite instructions in front. I did not instruct him explicitly on their use before, but aided when required.
Problems or other aspects with scenarios?	Had issues with keeping his altitude at appropriate levels (went too high). Managed to find Öckerö at high altitudes, but simulation constraints prevented him from finding a landing strip. Used built in map to navigate. Hard to manage speed and altitude when landing and had to go around. Was hard to relocate the airstrip again. Did manage to land, almost on the field.
Does the child seem to find it realistic / immersive?	
How comfortable does it seem to be?	
How fun is it to fly and be observed?	
Other notes	
Observation #13 (Handicap Viggen)	
What seems fun and what seems to take away from the fun?	Takes away: Joystick was very sensitive.
How is the learning going?	The instructions weren't clear (tried pressing the instructions themselves).
Problems or other aspects with scenarios?	Wasn't able to navigate without instructions, but managed to find Öckerö after a few suggestions. Managed to land, but speed was too far too high and he ended up taking off again.
Does the child seem to find it realistic / immersive?	
How comfortable does it seem to be?	
How fun is it to fly and be observed?	
Other notes	

TABLE XXVIII
DETAILED EFFORT BREAKDOWN

Data	Questionnaires	Interviews	Storyboarding	Focus Groups	Observations	Average
Creation of instruments	25	10.5	12	12	4	12.7
Total flying time	3.3	3.0	0.0	2.5	3.3	2.4
Total session time	0.7	1.5	2.3	0.5	0.0	1.0
Total participant effort	4.0	4.5	7.0	5.0	3.3	4.7
Requirements discovery	6.9	8.4	2.7	8.1	7.8	6.8
Total requirements elicitation effort	35.9	23.4	17.0	23.1	15.1	22.9
Note that the total requirements elicitation effort does not always include the full total participant effort. Example: A focus group session has several participants. A session with 5 participants of 15 minutes will add 0.25 person hours to the elicitation effort, but 1.25 person hours to the participant effort, since there are 5 participants.						

TABLE XXIX
USER STORIES WITH OCCURRENCES IN EACH TECHNIQUE AND CATEGORIZATION

User Story	I	O	FG	Q	S	FR / NFR	Categories
As a user I either want a reminder to release the parking brake or that the parking brake is not applied when I start out so I can immediately take off.	0	4	0	0	0	FR	Help/Reminder, Flight Controls
As a user I want a reminder to bring the landing gear up so I don't forget it.	0	1	0	0	0	FR	Help/Reminder, Flight Controls
As a user I want guidance to help me get started so I can start flying sooner.	0	4	0	0	1	FR	Help/Reminder
As a user I want help landing so it's not so hard.	0	5	2	1	0	FR	Help/Reminder, Flying
As a user I want help managing my speed so I can land correctly.	0	0	1	0	0	FR	Help/Reminder, Flying
As a user I want help staying on track and turning so I can fly around as I would like.	0	1	1	0	0	FR	Help/Reminder, Flying
As a user I want help staying on track while flying so I can travel straight ahead easily when I want to.	2	0	0	0	0	FR	Help/Reminder, Flying
As a user I want help staying straight on the runway when taking off so I don't have to crash.	1	1	0	0	0	FR	Help/Reminder, Flying
As a user I want help taxiing to the runway or start directly at the runway so I can start flying sooner.	0	1	0	0	0	FR	Help/Reminder, Situation
As a user I want help when trying to navigate so I can go where I want.	1	0	0	0	0	FR	Help/Reminder, Navigation
As a user I want it to be apparent where I can land so that I can land if I want to.	8	3	1	3	0	Both/either	Help/Reminder, Navigation
As a user I want many loud sound effects so I can get a higher feeling of realism.	0	0	1	0	0	NFR	Audio, Realism/Immersion
As a user I want navigation help so I can know where to go if I want to find a particular place or know where to land.	0	1	0	0	0	FR	Help/Reminder, Navigation
As a user I want some help knowing where I am so I don't get lost.	0	1	0	0	0	FR	Help/Reminder, Navigation
As a user I want text instructions so I can learn the basics on how to fly quickly.	0	0	1	0	0	FR	Help/Reminder
As a user I want the flight control stick to center automatically so I don't unintentionally steer in the wrong direction and crash.	0	2	0	0	0	FR	Flight Controls
As a user I want the graphics/scenery to be detailed and have many houses so it's realistic and fun to fly around.	5	0	0	0	0	NFR	Display/Graphics, Realism/Immersion
As a user I want the graphics/scenery to be detailed so it's realistic and fun to fly around.	0	0	2	0	0	NFR	Display/Graphics, Realism/Immersion
As a user I want the plane controls to work reliably in order to have an undisturbed flying experience.	0	4	0	1	0	NFR	Flight Controls
As a user I want the plane to be easy to control in a child-friendly way so I can go where I want to.	3	8	2	1	0	NFR	Flight Controls, Children Friendliness
As a user I want the plane to have weapons so the simulation is more fun and realistic.	0	0	0	2	1	FR	Gameplay, Realism/Immersion
As a user I want the relevant controls to be clearly labeled so I know what they do.	0	0	2	0	0	FR	Help/Reminder, Flight Controls
As a user I want the runways to be clearly distinguishable from normal roads so I can know where it's possible to land.	0	0	1	0	0	NFR	Display/Graphics, Navigation
As a user I want the seat to be comfortable so I can focus on flying.	0	1	0	0	0	NFR	Physical Environment
As a user I want the simulator to be a bit covered / protected so I'm not distracted by people standing nearby trying to talk to me.	0	1	0	0	0	NFR	Physical Environment, Realism/Immersion
As a user I want the simulator to provide physical feedback (e.g. rotating) so I can get a higher feeling of realism.	0	0	0	1	0	FR	Physical Environment, Realism/Immersion

I = $\sum$ Interviews; O = $\sum$ Observations; FG = $\sum$ Focus Groups; Q = $\sum$ Questionnaires; S = $\sum$ Storyboarding
FR = Functional Requirement; NFR Non-Function Requirement

TABLE XXX
USER STORIES WITH OCCURENCES IN EACH TECHNIQUE AND CATEGORIZATION, CONT.

User Story	I	O	FG	Q	S	FR / NFR	Categories
As a user I want the simulator to provide physical feedback (e.g. vibrations) so I can get a higher feeling of realism.	1	0	2	0	0	FR	Physical Environment, Realism/Immersion
As a user I want to be able to adjust my seat height so I can see out properly.	0	0	1	0	1	FR	Physical Environment, Children Friendliness
As a user I want to be able to do acrobatics so I can have fun.	7	1	0	0	1	NFR	Flying, Gameplay
As a user I want to be able to enter and exit the simulator without significant difficulties so I don't risk injury to myself.	0	1	0	0	0	NFR	Physical Environment
As a user I want to be able to fly at a high speed (and it should feel that way) so it's fun and realistic to fly.	1	0	0	0	0	NFR	Realism/Immersion, Flying
As a user I want to be able to fly by local landmarks so I can have fun.	2	0	0	0	0	NFR	Realism/Immersion, Navigation
As a user I want to be able to see the environment when looking out any window so I that it's more realistic and fun.	1	2	0	0	0	NFR	Physical Environment, Display/Graphics
As a user I want the simulator to be reliable enough that it's possible to take off after landing so I'm not stuck on the ground.	0	0	0	1	0	NFR	Flying
As a user I want to experience G-forces in some way so it's more realistic.	0	0	0	1	0	FR	Realism/Immersion, Gameplay
As a user I want to feel the cold grip of death looming around me when flying so I may feel a greater sense of realism and fear of failure while flying.	1	0	0	0	0	NFR	Realism/Immersion, Gameplay
As a user I want to have a display solution that I can easily use so I can focus on flying.	1	0	0	0	0	NFR	Display/Graphics, Physical Environment
As a user I want to have a feeling for where I am and where I can fly so it's more fun.	1	0	0	0	0	NFR	Realism/Immersion, Navigation
As a user I want to have a good view so it's easy to see the world.	0	1	1	0	0	NFR	Display/Graphics, Physical Environment
As a user I want to have a map when flying so I can see where I am.	2	0	0	0	0	FR	Navigation, Display/Graphics
As a user I want to have an immersive simulation experience so it feels like I am flying the real plane.	2	0	0	0	0	NFR	Realism/Immersion
As a user I want to listen to prerecorded audio instructions before flying so I can learn the basics on how to fly quickly.	0	0	1	0	1	FR	Help/Reminder, Flying
As a user I want to start on the runway so I don't have to taxi to the runway before taking off.	0	2	0	1	0	FR	Situation
As a user I would like to be able to fly at different locations so I can see more different places.	0	0	1	0	0	FR	Situation, Gameplay
As a user I would like to have a map so I can know where to land.	0	0	1	0	2	FR	Navigation, Display/Graphics
As a user I want the flight controls to not require too much force to move them so I can move them even though I'm a child	0	0	0	1	0	NFR	Flight Controls, Children Friendliness
As a user I want to be able to sit on something extra high (e.g. a cushion) if I need to so I can see everything and use all controls properly.	0	0	0	0	1	FR	Physical Environment, Children Friendliness
As a user I want to have a challenge involving eating clouds so I can have fun while flying.	0	0	0	0	1	FR	Gameplay
As a user I want to be able to fly among a lot of clouds so it's more fun to fly around.	0	0	0	0	1	NFR	Realism/Immersion
As a user I want to be able to fly to Tokyo so I'm not limited to flying near my actual local area.	0	0	0	0	1	FR	Situation, Gameplay

I = $\sum$ Interviews; O = $\sum$ Observations; FG = $\sum$ Focus Groups; Q = $\sum$ Questionnaires; S = $\sum$ Storyboarding
FR = Functional Requirement; NFR Non-Function Requirement